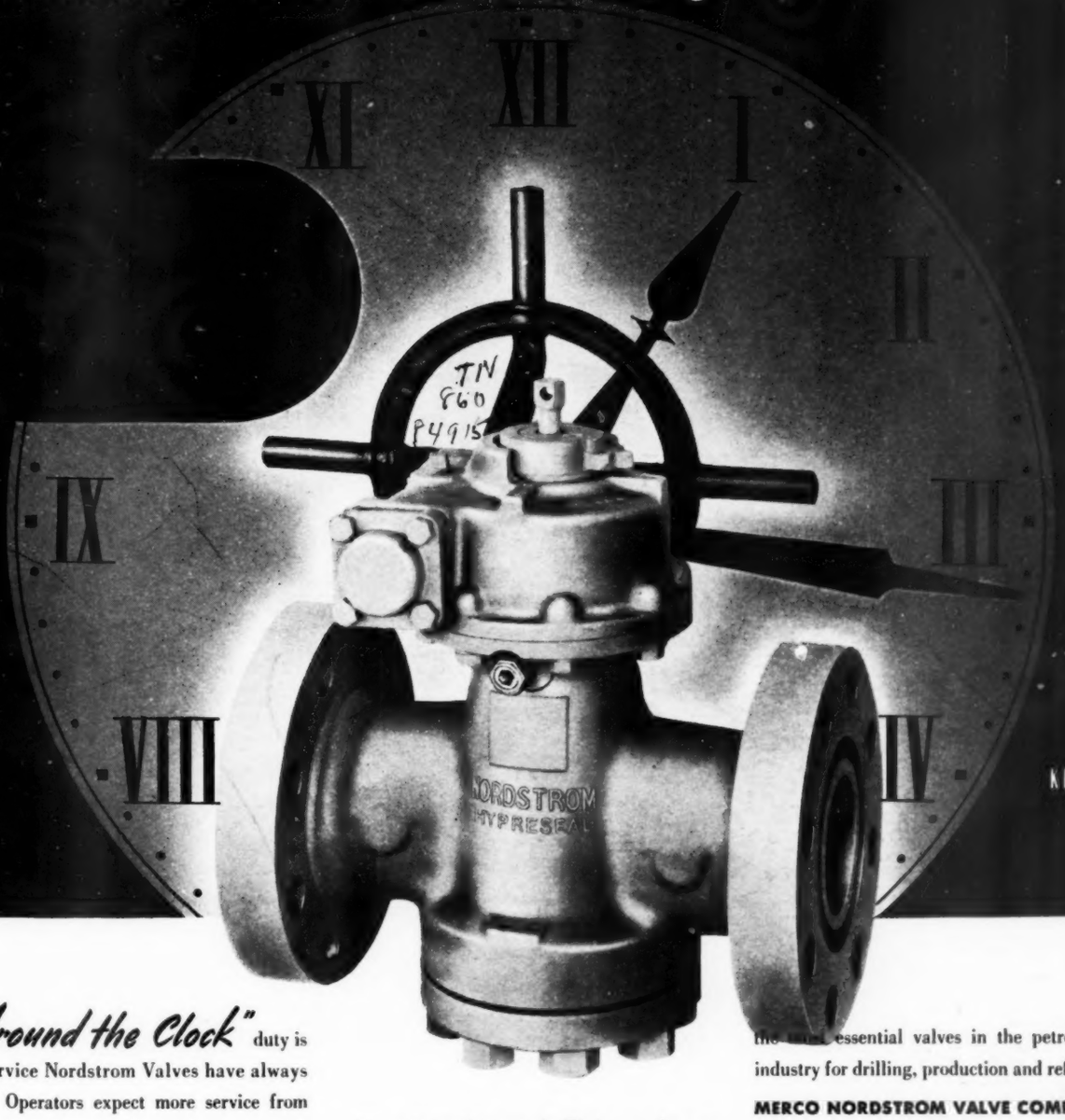
DRILLING
AND PRODUCTION

PIPE LINE

REFINING
NATURAL GASOLINE

WAR HAS NO SUNDAYS



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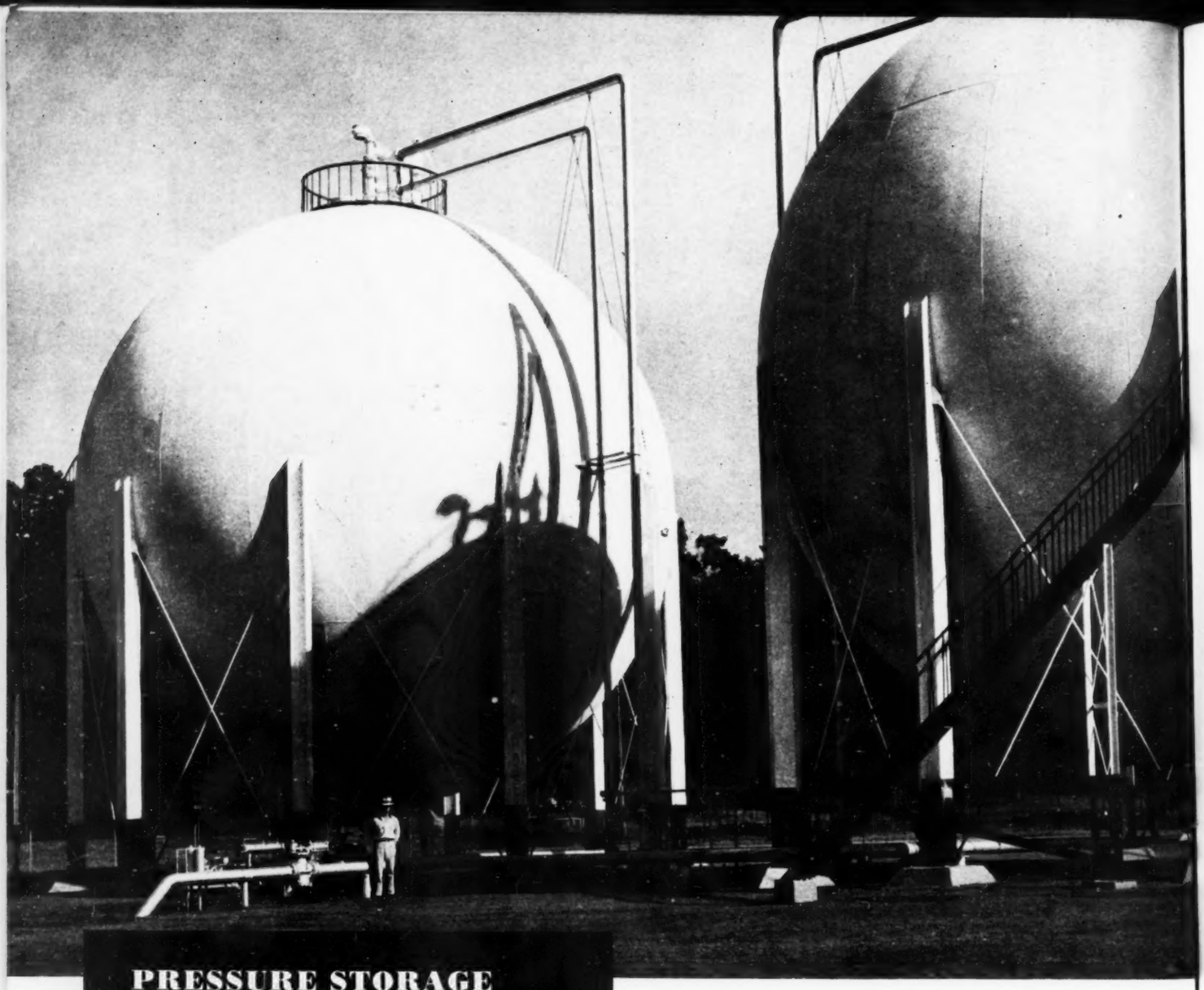

PRESSURE STORAGE versus *Evaporation* in HORTONSPHERES

THERE'S a battle in the petroleum industry that has no armistice . . . *pressure storage vessels against the forces of evaporation!*

In the handling of butane, butadiene, toluene, 100 octane gasoline and other volatile oil products, Hortonspheres are serving as potent weapons against loss by evaporation and product deterioration. These vapor-tight pressure vessels are designed to withstand pressure built up in the vapor space at normal temperatures, without venting; and the fact that pressure does build up in the sphere is proof that no vapor is being lost.

Hortonspheres are built in capacities of 1,000 to 20,000-bbls. — for pressures from 20 to 100-lbs. per sq. in.

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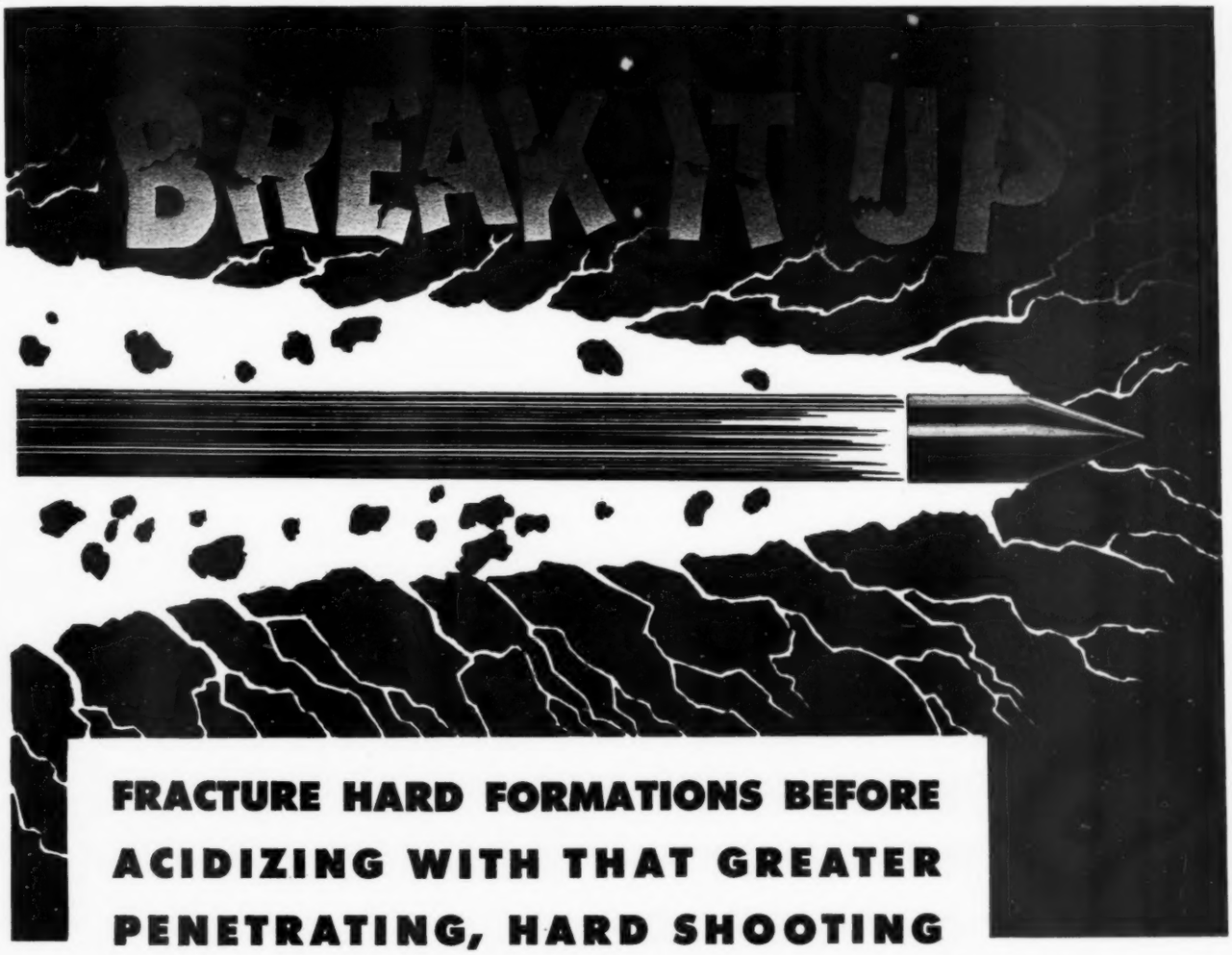

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By using the maximum powder charge and scientifically confining the gases, McCullough Gun Perforators fire bullets with extremely high velocity. The high velocity bullets produce CLEAN HOLES in the casing, penetrate far into the formation, and effect maximum shattering of limestones. The multitude of cracks and fissures thus created enable acid to penetrate and work most effectively in opening up a network of channels through which oil can pass freely into the well. Before acidizing—call out that greater penetrating, hard-shooting McCullough Gun Perforator, anytime day or night.

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April, 1943

THE Petroleum Engineer

VOL. XIV No. 7

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A Magazine of Methods for Operating Men

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MEMBER A. B. C.—A. B. P. (The articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N. Y.

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SIMPLIFICATION ★ A VICTORY AID!

Proven Instruments take up New Tasks!

A sidelight on the "miracles" fast shaping in petro-chemical plants . . .

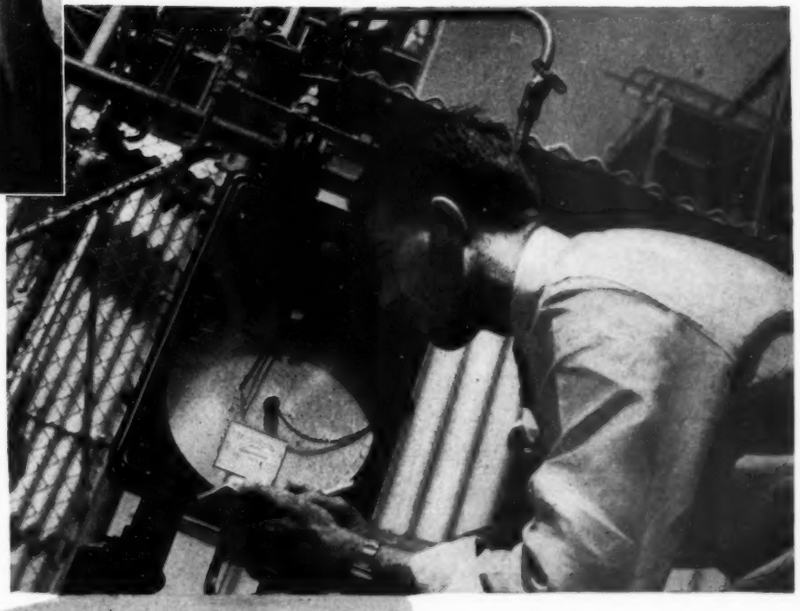
PILOT PLANTS can afford to be daring. But when experimentation passes into full-scale operation, standardization and rigid control rule every phase of production in petro-chemical industries.

These vital war plants take no chances with untried process equipment or instruments for the sustained accurate measurement and control demanded.

Here are glimpses of a vast new plant devoted to the production of butadiene for synthetic rubber manufacture, as well as an output of 100-octane gasoline and toluol.

The Metric-American orifice meters shown are typical of the plant equipment . . . instruments which have proved themselves in the Petroleum and Gas industries . . . and which give safe assurance of fitness for their present important tasks.

METRIC-AMERICAN orifice meter in the alkylation plant of a subsidiary of a large oil company.



METRIC-AMERICAN orifice meter—with catalytic cracker in background.

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1945

The Course of Oil

by K. C. SCLATER

NOTES ON RESERVES

Possibilities for increasing the nation's available oil reserves was the dominant topic of discussion among geologists and geophysicists at their annual meeting at Fort Worth last week. Surveys were made to obtain an overall picture of the areas for prospecting and the chances they offer for increasing oil reserves. According to reports submitted, geologists as individuals are not so pessimistic over the dearth of good drilling prospects as are oil company executives.

Current estimates of available oil reserves, DeGolyer, Assistant Deputy P.A.W., thinks are low. His observations over the years have been that estimates of reserves always have had to be revised upward. Present estimates of crude reserves of the United States are probably nearer 30 billion barrels than 20 billion barrels of oil. He asserted that over a period of years crude oil reserve estimates have been shown to be approximately 175 percent low.

It is generally conceded that except for about two areas, the Gulf Coast and West Texas, all fields in the country are producing at capacity. West Texas could still produce a much greater volume of oil without exceeding an optimum rate of flow, but it lacks adequate transportation facilities. Owing to declining production in the Mid-Continent there is apprehension that by next year fields now supplying midwest refiners may be unable to meet demands. Application has been made to Washington officials for a pipe line from West Texas to connect with pipe line facilities in Oklahoma. The line would have a capacity of 54,000 barrels daily, or if the necessary pumping equipment were available, about 116,000 barrels daily.

With an overall drilling program of 16,000 wells for 1943, of which 4500 will be wildcats, there is little assurance that additions to the nation's reserves will be adequate. Indeed, new oil reserves are likely to fall dangerously short, unless, of course, there should be a lucky strike and another East Texas discovered. With the drilling restrictions now in force it is unlikely that a field of the East Texas type will be discovered. Other than actual drilling, geological or geophysical methods now in use do not offer much hope of discovering a field of this type.

Wildcat drilling still lacks a price incentive. Deep prospects, which cost money, are not encouraged by present crude prices. Vetoing of the Bankhead Bill and the freezing of prices by the President in his drastic order of a few days ago do not lend much support to the prospect of a general price increase at this time, despite the fact that oil withdrawals during 1943 and 1944 to meet war demands will seriously deplete the known available oil reserves of the United States. The longer the delay in taking the necessary steps—making sufficient materials available and granting a general increase in the price of oil—the more drastic the action that must eventually be taken to uncover new reserves and make them immediately available.

It now seems evident that Petroleum Administrator Ickes may be reluctant to make a further request for a price increase at this time. The President's order came only thirty hours after the Petroleum Administrator had made a recommendation to the O.P.A. regarding a price increase.

Reluctance in granting a general crude price increase cannot be reconciled with the vital war needs for petroleum and the exigency of a possible shortage. There may be factors of military strategy that enter. Success of Allied arms in Tunisia and the opening-up of the Mediterranean to Allied shipping will have a far-reaching effect on supplying the fighting forces. Most of the petroleum needs of the Allied armies in the Near East and in Europe could be supplied by the fields and refineries of Iraq and Iran. Pending the outcome of the battle in Tunisia authorities in Washington may be marking time. At present there seems to be no disposition to grant the industry more materials than that necessary for the 16,000-well program decided upon for this year, despite the imperative national need for new oil reserves, and the apparent concern of the P.A.W. to do everything possible to encourage the oil industry to increase those reserves.

Although material and manpower shortages and low crude prices have influenced the declining discovery rate there are other angles to the problem. Data show that "without the opening of new prospecting territory, discovery rates could not have been maintained." Of the various oil-finding methods the records show that there has been a rapid increase in the amount of oil discovered soon after the inception of each new method and that each method is now in a period of lessened effectiveness. Obviously, "without the introduction of new finding methods, total discoveries would have been much smaller. Our finding tools are less effective today than at any time heretofore from the standpoint of the volume of oil being found, and further illustrate the extreme need for developing new prospective territory in the Mid-Continent Rocky Mountain-Gulf Coast region if the discovery rate is to be maintained. These two factors have profoundly influenced the discovery rate over the past three to seven years, and, in my judgment, have been major causes of its decline." These were some of the factors influencing the declining rate of crude oil discoveries offered by L. F. McCollum in a paper presented at Fort Worth.

In the face of these admissions, greater encouragement must be given to the wildcatter. Give him the necessary material and an increase in crude price, and, if sufficient manpower is still available and unnecessary restrictions are removed, he will produce the greatest results with the least delay.

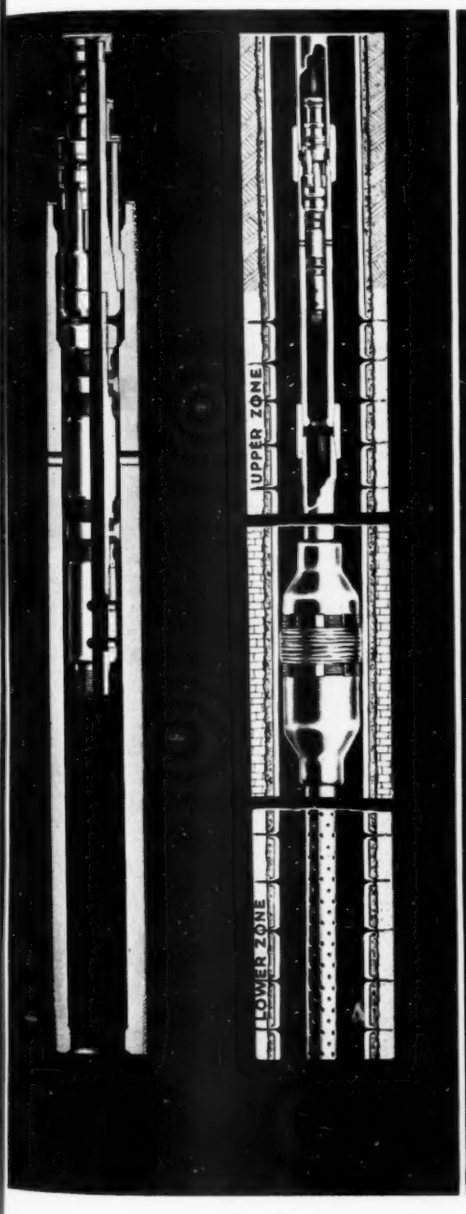
OTIS PRESSURE CONTROL SERVICE - EQUIPMENT

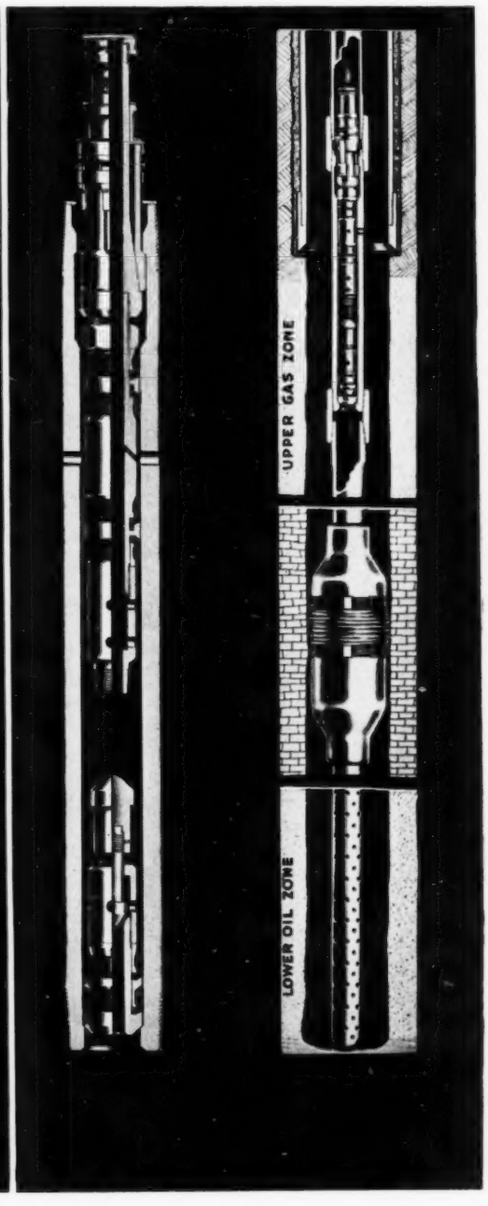
Sul-Sulphur Facts

ON THE
CONTROL OF FLOWING WELLS

No. 3 | 1943 | DALLAS, TEXAS

TWO-ZONE COMPLETIONS SIMPLIFIED .. Otis Type G Side-Door Choke Provides Means to Take Bottom Hole Pressure of Each Zone Independently of the Other without Moving the Tubing...





Proved practical by many hundreds of installations, the Otis Type G Choke furnishes a means for opening or closing circulating ports in the tubing string, a short distance above the packer, after the packer has been set and surface connections permanently installed.

This makes it possible to establish circulation and to completely unload both zones safely without moving the tubing or changing any of the surface connections. After the tubing and annular space are unloaded, the circulating ports are closed simply by setting the Side-Door Choke. This completely separates the two zones and permits them to be produced independently of each other.

The Type G Side-Door Choke consists of a locking device and a pack-off section. The locking device is simple, rugged, and locks only when in its landing nipple. The pack-off section consists of a cup mandrel on which are mounted four pressure-seal fabric cups. These cups are placed so that two will be above and two below the circulating ports when the choke is in set position. This arrangement completely blanks off all flow through the ports, regardless of whether the greater pressure is from the upper or lower zone.

SIDE-DOOR CHOKE A VERSATILE TOOL *Has Many Uses*

PROVIDES A MEANS TO:

1 Take Bottom Hole Pressures of either zone independently of the other without moving tubing. By equipping choke with cup mandrel which has open vertical bore and side ports, the upper zone is packed-off and pressures can be taken of lower zone only. Conversely, by using cup mandrel which has lower end of vertical bore plugged, but with side ports, the lower zone is packed-off and pressures can be taken of upper zone only.

2 Circulate or Swab-In Annulus after packer has been set and all connections permanently installed. Circulating ports in landing nipple are closed after both zones have been brought-in simply by running Side-Door Choke.

3 Kick off the Annulus should it become loaded up. The circulating ports in the landing nipple are opened simply by removing the Side-Door Choke, thereby permitting the annulus to be unloaded.

4 Utilize gas from an overlying gas zone to assist oil to flow from a lower zone. By equipping the choke with a small side orifice in the cup mandrel, a controlled volume of gas from the upper zone enters the tubing, reducing the weight of the oil column, and causing the lower zone to flow. A removable back pressure valve in the lower end of the choke landing nipple prevents the upper zone from charging the lower zone.

INSTALLED UNDER PRESSURE ON STEEL LINE

The Otis Type G Side-Door Choke is run or pulled under pressure on an ordinary steel measuring line without disturbing the tubing or well pressure. The pulling of these chokes, particularly where the two zones have a considerable differential in bottom hole pressures, has been greatly simplified by a special equalizing device constructed within the choke.

OTIS PRESSURE CONTROL, INC.

DALLAS, TEXAS

Branches: Houston and Corpus Christi, Texas; Hobbs, New Mexico; New Iberia, Louisiana; Magnolia, Arkansas.

Representatives: Otis Eastern Service, Inc., Wellsville, N. Y.; Western Pressure Control, Los Angeles and Bakersfield, Calif.

Export Office: 74 Trinity Place, New York City

Highlights IN OILDOM

New Texas Rules for Oil Conservation

The Texas Railroad Commission has announced additional state-wide rules and regulations designed to conserve the state's natural resources by preventing waste of crude oil and natural gas.

The rules are as follows:

Rule 44. A blowout preventer, control head and other connections for keeping the well under control at all times shall be installed as soon as surface casing is set.

Rule 45. All wells shall be equipped with a bradenhead. Whenever pressure develops between any two strings of casing, the agent of the commission shall be notified immediately. No cement may be pumped between any two strings of pipe at the top of the hole, except after permission has been granted by the commission's agent in charge of the district in which said field is located.

Rule 46. All wells shall be cleaned into a pit not less than 40 ft. from the derrick floor and 150 ft. from any fire hazard.

Rule 47. All flowing wells must be produced through an oil and gas separator of ample capacity and in good working order. Sufficient tankage shall be provided on each lease to permit the proper taking of the allowable production. Lease or working tanks shall be so operated as to permit proper gauging.

Rule 48. All wells shall be equipped with adequate chokes, or beans, properly to control the flow thereof.

Rule 49. No boiler or electric lighting generator shall be placed or remain nearer than 150 ft. to any producing well or oil tank.

Any rubbish or debris that might constitute a fire hazard shall be removed at least 150 ft. from the vicinity of wells, tanks, and pump stations. All waste shall be burned or disposed of in such manner as to avoid creating a fire hazard.

Rule 50. All permanent oil tanks, or battery of tanks, must be surrounded by a dike or firewall, with a capacity of at least one and one-half times that of the capacity of the tank or battery of tanks.

Rule 51. When coming out of the hole with the drill pipe, drilling fluid shall be circulated until equalized and a fill-up line shall be turned into the casing to insure a full load of fluid on the bottom of the hole at all times.

Rule 52. All wells producing 2 percent or more salt water must be reported by their owner or operator to the commission's agent in the district in which the well is located, or to the commission's office at Austin, Texas.

Rule 53. The authorized agent of the commission is hereby authorized to make gas-oil ratio or bottom-hole pressure tests on any well at any time and the owner of such well is hereby directed to do all things that may be required of him by the commission's agent properly to make such tests.

Salt Water Disposal Facilities For Gladewater Area

The East Texas Salt Water Disposal Company has announced the installation of a salt water disposal system to serve the area south and west of Gladewater in the Chote, Dillard, and Hokit surveys.

A salt water disposal well will be drilled from the surface on the western limits of production in the Dillard survey. In recognition of the help that has been given the East Texas Salt Water Disposal Company by C. R. Starnes of Gladewater, the company has named the disposal well the C. R. Starnes No. 1 and the disposal system including the pipe lines and treating plants will be known as the C. R. Starnes salt water disposal system.

The company has already let the contract to drill the well to the Hollandsworth Drilling Company of Gladewater.

This is the second salt water disposal system to be installed by the East Texas Salt Water Disposal Company in the Gladewater area. The other system serves the Augustine, Goodwin, Thompson-Allen, and Evans surveys. The disposal well is located in the southwest part of the Goodwin survey on the Phillips-L. J. Everett lease. The system has been in operation approximately two weeks and is taking care of all the water produced in the area served.

Urge Raising of Crude Oil Price Ceiling

A 21-man delegation headed by Frank Buttram, president of the Independent Petroleum Association of America, early this month urged Petroleum Administrator Ickes to recommend to the Office of Price Administration an increase in price ceilings for crude oil. Buttram stated the increase would be necessary to avert a shortage of petroleum in the near future, and also to avert the "practical disintegration of the independent producing division of the petroleum industry."

"Independent producers, who year after year find about three-fourths of the new fields and produce nearly 50 percent of all oil, are today unable to carry out the exploratory efforts to discover new sources of oil supply which they know must be performed and which they are best fitted to do," he said.

"The independent producers are being driven from business. For four years prior to the present emergency, with materials and manpower plentiful, new discoveries were diminishing. That condition resulted through the control of crude petroleum by the major purchasing companies. Today, the same result—price control—is being accomplished by government agencies. The effect continues to be the same.

"Although the need for crude petroleum is increasing, the ability to supply it has decreased rapidly under the present system. Our crude petroleum production for January, 1943, was 356,000 bbl. a day less than in January, 1942. Our above-ground stocks of petroleum and products were reduced more than 50,000,000 bbl. in 1942. Our new discoveries last year reached the lowest point in the modern history of the industry.

"Petroleum activities are now completely controlled by governmental agencies. No specific effort to increase the industry's ability to meet the increasing demand has been made effective by these agencies. It is our hope that they will take the necessary action before the petroleum supply situation takes on the proportions of a debacle."

Price increases would help overcome manpower shortage resulting partly from departure of skilled men to take higher-paying jobs in other industries, the delegation said, and would stimulate wildcatting operations to meet Ickes' request for the drilling of 4500 exploratory wells this year.

Secondary Recovery Bill Killed

The Oklahoma legislature recently killed the secondary recovery bill known as the Batson Bill, which was sanctioned by Governor Kerr. Proponents of the bill said repressuring would serve as a means of producing 500,000,000 bbl. of oil available in no other manner. Opponents declared small operators and royalty owners could be forced into the program against their will.

Principal opponents declared they did not oppose repressuring itself, but criticized the terms of the bill under which plans would be devised whereby the Oklahoma Corporation Commission could authorize unitization for repressuring purposes.

A PENBERTHY GAGE
FOR EVERY PURPOSE

All Penberthy Gages conform with A.S.M.E., Federal and State requirements when used for pressures specified by their respective codes.

Reflex Water Gage Set designed for oil field boilers.

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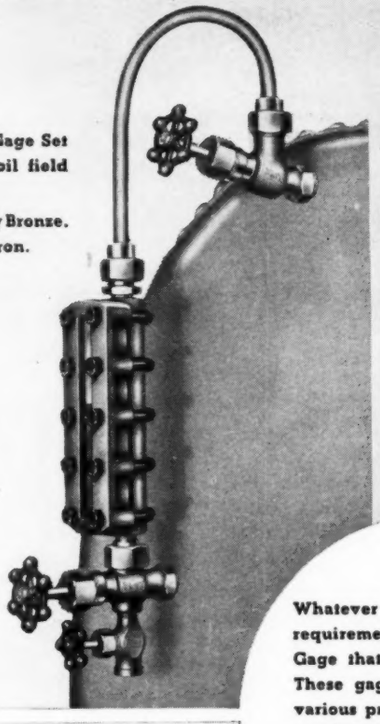
Type B—All Iron.



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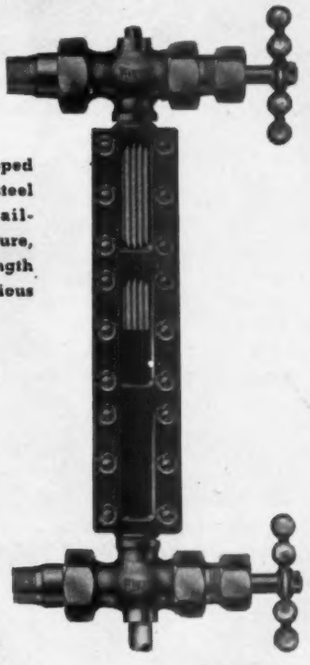

Whatever your liquid level gage requirements, there is a Penberthy Gage that will meet your needs. These gages are suitable for the various pressure and temperature requirements of the oil industry. Write for a copy of new catalog.

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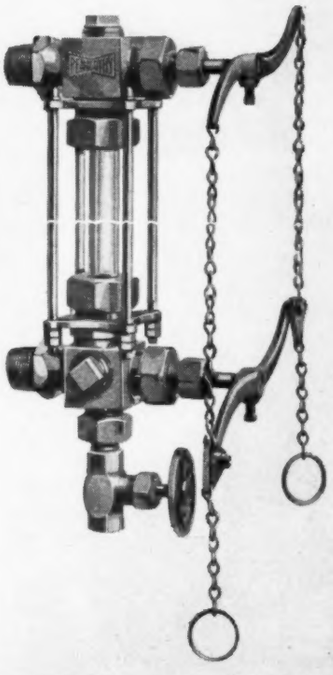

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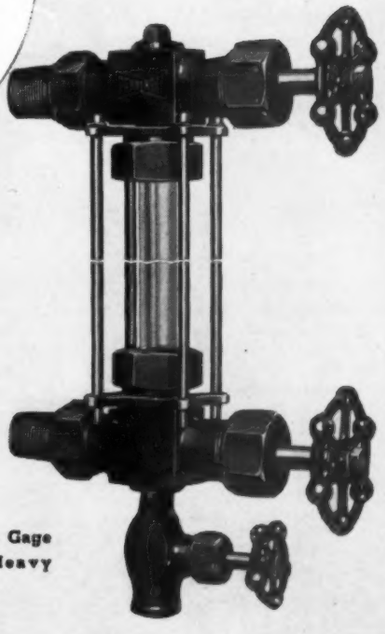
Extra Heavy Bronze



All Iron Gage
Extra Heavy

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MAJOR *Refining* ACTIVITIES

THE Chicago Corporation and Gulf Plains Corporation, operators of three cycling plants in the Stratton and Agua Dulce fields in Nueces County near Corpus Christi, Texas, have installed facilities to recover butane and propane at their respective plants. Final completion of the plants is scheduled for May. The two plants operated by the Chicago Corporation have capacity for treating 120,000,000 cu. ft. of gas per day and the Gulf Plains plant has a capacity of 125,000,000 cu. ft. per day. One of the Chicago plants will produce 720 bbl. per day of butane and 650 bbl. per day of propane, while the other will recover 720 bbl. per day of butane and 600 bbl. per day of propane. Additions to the Gulf Plains plant will permit recovery of 730 bbl. per day of butane and 620 bbl. per day of propane.

H. D. Collier, president of Standard Oil Company of California, revealed in a report to stockholders that the company had invested approximately $42,000,000 in 1942 for additions to refinery plants and equipment.

Present plans of the company call for large increases in the production of high octane aviation gasoline for the year 1943. Collier reported that increased deliveries of petroleum products to governmental agencies by the company in 1942 more than offset the effects of decreased civilian use of automobiles. "Hydrocarbons which constitute petroleum are a chemical storehouse of vast potentialities, some of which are only now revealing themselves to our view, with others probably yet to be discovered," Collier stated, in referring to the position petroleum has already attained and is expected to expand to after the war as the source of hundreds of chemicals.

The first carload of helium has been shipped from one of the five new helium plants being built by the federal government. Work is being rushed on the remaining plants for completion, it has been announced.

In a report to Harold L. Ickes, Secretary of the Interior, Dr. R. R. Sayers, director of the Bureau of Mines, said that the four remaining plants, under construction, are located " in the Southwestern area" and that by the end of this year the bureau will have six plants turning out helium for war needs. The new plant, in Texas, is producing below its capacity to break in equipment properly. Some equipment is still being added and when completed the plant will have a larger capacity than the Amarillo, Texas, plant built in 1939, which at present is producing the helium for the Navy antisubmarine blimps and other war uses. Two of the four plants not completed are reported to have a capacity equal to the Amarillo plant, which has been enlarged, but will be only about half as large in size

The Anco Gas Corporation, operating a cycling plant in the Long Lake field near Palestine in Anderson County, Texas, is constructing facilities for production of liquefied petroleum gases (butane and propane). Capacity of the plant is 50,000,000 cu. ft. of gas per day.

Recovery of *iso*butane at the Walton natural gasoline plant near Kermit, in Winkler County, Texas, is planned by the Cabot Carbon Company. The plant has a recovery of 45,000 gal. per day of natural gasoline.

Announcement has been made that construction will be completed this year on the National Refining Company aviation gasoline plant, being built by Defense Plant Corporation, in Findlay, Ohio. Construction of facilities to modernize the crude distillation unit was begun in 1941. When completed the plant capacity had been increased from 6000 to 9000 bbl. per day. In January, 1943, construction of a selective catalytic polymerization unit was completed, which was designed to produce codimer, a blending agent for aviation gasoline.

A plant costing approximately $2,500,000 for the manufacture of catalyst for catalytic refinery operations has been completed and is in operation in Fort Worth, Texas, by American Cyanamid and Chemical Corporation. Construction work was completed by Chemical Construction Company and the project was financed by Defense Plant Corporation.

Plants similar to the Fort Worth plant are under construction at Corpus Christi, O'Donnell, and Brownfield, Texas. Operation of the Texas plants is under the supervision of W. L. Spalding, manager for the American Cyanamid and Chemical Corporation.

The Cities Service Oil Company (Delaware) expects to have their sulphuric acid alkylation plant and butane isomerization facilities for production of aviation gasoline in operation this month. The plant is located at the East Chicago refinery.

The Cities Service Refining Corporation, a subsidiary, is constructing a refinery to process 70,000 bbl. of crude oil per day to produce maximum quantities of aviation gasoline. Processes being installed include fluid catalytic cracking units, sulphuric acid alkylation units, and butane isomerization facilities. Large quantities of essential products such as feed stock for one of the largest government-owned butadiene plants, to be operated by Cities Service Refining Corporation will be produced by the plant. Arkansas Fuel Oil Company, another subsidiary of Cities Service, is engaged in converting parts of its refining equipment to be used in the purification of crude butadiene for government use.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended March 27, 1943
A.P.I. Figures
(Figures in thousands of bbl. 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Production	Total Gas and Fuel Oil Stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	88.7	1,722	70.5	9,768	64,929
Appalachian	84.8	158	89.3	787	3,825
Ind., Ill., Ky.	85.0	715	88.2	4,022	26,364
Okla., Kans., Mo.	80.1	340	81.7	1,923	9,330
Rocky Mountain	48.0	85	57.8	487	2,960
California	89.9	722	88.4	4,803	84,589
TOTAL U. S.— B. OF M. BASIS MARCH 27, 1943	86.2	3,742	77.8	21,790	(a)192,997
TOTAL U. S.— B. OF M. BASIS MAR. 20, 1943	86.2	3,618	75.2	21,395	192,161
U. S. B. OF M. BASIS MARCH 28, 1942	.....	3,633	.....	21,681	223,338

(a) Finished 83,864,000 bbl.; Unfinished 10,215,000 bbl.

*At the request of the Petroleum Administrator for War.

[1]Production—total of gasoline at refineries including natural and blended; gas oil and distillate fuel, and residual fuel oil.

[2]Stocks—at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; gas oil and distillate fuel, and residual fuel oil.

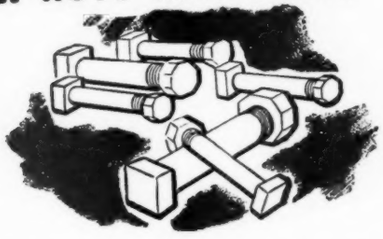
Welding piping with Tube-Turn fittings conserves 4 vital materials . . . checks war-time pipe failures, stops leaks!

NO. 4 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

★ The ★ FIRST WELDING FITTINGS 1ST AND STILL THE BEST

1. NUTS AND BOLTS

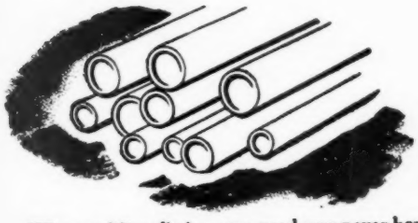


Joints welded with Tube-Turn fittings require no nuts or bolts. Maintenance time and trouble spent in tightening bolts is eliminated.

2. FLANGES

Welding fittings supplant the need for many of the flanged joints necessary in screwed piping—save both weight and critical metal.

3. PIPE REPLACEMENT



When welding fittings are used, you never have to replace any pipe because of worn threads or damage due to replacing flanged fittings.

4. GASKET MATERIAL

Fewer flanged joints mean fewer gaskets to replace. No materials or time wasted when connections are welded with Tube-Turn fittings.

When you multiply these savings over an entire piping system, the amount of critical materials conserved is tremendous. Tube-Turn welding fittings aid the war effort in *other* ways, too—less danger of plant shut-downs due to piping failures; maintenance is virtually eliminated; less installation time is needed because alignment is easier, only simple butt welds are required, and complete sections may be pre-assembled then welded into position. For *stronger, lighter, permanently leakproof* piping systems—weld with Tube-Turn fittings!

TUBE-TURNS (INC.) LOUISVILLE, KY. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Tulsa, Houston, Los Angeles. *Distributors in principal cities.*

TUBE-TURN

TRADE MARK

Welding Fittings and Flanges

MAJOR *Oil Field* ACTIVITIES

ACADIA PARISH, Louisiana, has a new field opened by Sun Oil Company with J. R. Daily No. 1, seven miles west of Crowley in section 31-9s-1w. Drilled to 10,871 ft. after setting a string of protection pipe to 8767 ft., the well encountered shows that are believed to be in what is known as the Lewisburg zone of the Miocene section. At last report the operator was setting casing to make the first flow test.

A new pool was opened in the Charco Blanco area of southern Starr County, Texas, when the Ike Howeth, E. P. Caffarelli No. 1 wildcat flowed an estimated 70 to 80 bbl. per day. The well is flowing from a sand at 3609-26 ft. into tanks through a ⅛-in. tubing choke under pressure of 200 lb. with 900 lb. on the casing. Production is from the Pettus sand in the Cockfield zone, which is also known as the Cockfield-Yegua.

The Steamboat Butte pool of Fremont County, central Wyoming, has been opened with a new producing well in the Sundance formation. Drilled by The British American Oil Producing Company, the new area received its inception from No. 1 Tribal E, in NEC NW NW, 5-3n-1w, about 32 miles north of Lander. Oil showed in cuttings from the Muddy, Dakota, and Lakota formations, topping the Sundance formation at 5094 to 5118 ft. Cores from 5097 to 5099 ft., from 5099 to 5109 ft., and from 5109 to 5118 ft. showed oil. A drill-stem test with packer set at 5093 ft. and with total depth of 5109 ft. showed 5092 ft. of oil and 182 ft. of oil-cut mud with the tool open one hour. Pipe was run and cemented to 5092 ft. Nearest production is in the Pilot Butte pool two and one-half miles southwest, which is from the Tensleep formation.

Adams No. 1, J. J. Fleet et. al., in CSE NW of 8-14w-7e, east of the old Stroud field in Creek County, Oklahoma, is apparently the discovery well of a new field. The well was estimated to produce between 100 and 150 bbl. per day on first tests. Casing, 7-in., was set at 2860 ft. with the top of the Prue sand found at 2872 ft. Total depth of the well is 2885 ft.

The Sinclair Wyoming Oil Company and J. E. Bauer have opened a new oil pool one-half mile northeast of St. Francisville pool in Lawrence County, Illinois. Brevoort No. 1, in SW NW SW of 11-2n-11w, found little show in the Bethel sand, however, the McCloskey lime from 1859 to 1863 ft., after being treated with 2000 gal. of acid, made 105 bbl. of oil and 5 bbl. of water per 24 hours. Total depth of the well is 1867 ft.

Cities Service Oil Company and Stanolind Oil and Gas Company and Derby Oil Company have opened two new oil pools in Kansas. In Stafford County, Cities Service Oil Company Grunder No. 1, SW NE NE, 11-25-15w, seven miles southeast of the Macksville pool, has been assigned a potential of 46 bbl. of oil per day from the Kansas City lime. Stanolind Oil and Gas Company and Derby Oil Company have a discovery well in Van Lieu No. 1, in NE SE NE, 20-24-13w, one mile northwest of the St. John pool and two and one-half miles south of the town of St. John. It is expected that the area may be declared an extension of the St. John pool. A temporary potential of 104 bbl. per day from the Arbuckle dolomite has been assigned to the well. M. Billings has opened a new pool with Krug No. 1 in the NEC SW, 8-14-14W, in Russell County.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.45-1.15	Kentucky	1.32-1.43
Colorado	1.05-1.07	Indiana	.85-1.25
New Mexico	.70-1.15	Ohio	
Texas		Lima	1.50-1.60
North Central	.97-1.21	Michigan	1.24-1.44
Panhandle	.70-1.12		
West Texas	.80-1.27	Pennsylvania	
Gulf Coast	.93-1.48	Bradford	3.00
Darst Creek	1.14	Southwest	2.65
East Texas	.80-1.27	Eureka	2.59
Talco	.79	Buckeye	2.30
Kansas	.93-1.25	Corning	1.31
Oklahoma	.75-1.25		
Arkansas	.94-1.36		

DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.

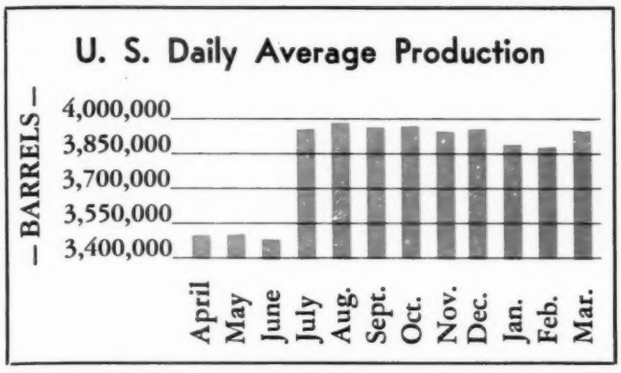
(Figures in bbl. of 42 gal. each)

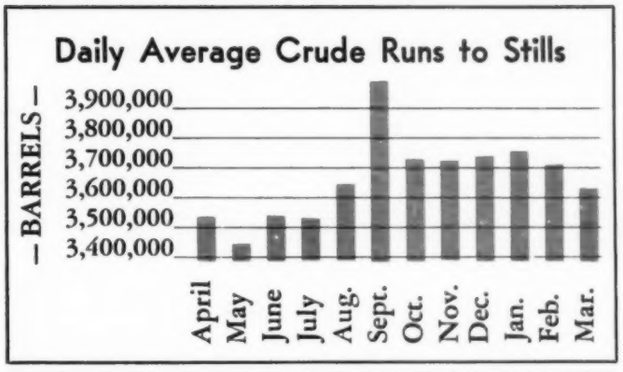
	[1]P.A.W. Recommendations March	Week Ended Mar. 27, 1943	Week Ended Feb. 27, 1943	Week Ended Mar. 28, 1942
Oklahoma	390,700	390,700	350,450	387,350
Kansas	309,900	309,900	306,400	238,900
Nebraska	2,800	.....	2,550	4,150
Panhandle Texas	.....	.....	88,900	89,200
North Texas	.....	.....	135,350	148,800
West Texas	.....	.....	213,900	233,200
East Central Texas	.....	.....	102,250	90,000
East Texas	.....	.....	325,100	368,200
Southwest Texas	.....	.....	166,350	195,850
Coastal Texas	.....	.....	319,600	284,900
TOTAL TEXAS	1,502,000	[2]1,501,801	1,351,450	1,410,150
North Louisiana	.....	.....	89,750	81,100
Coastal Louisiana	.....	.....	246,550	253,800
TOTAL LA.	349,800	370,300	336,300	334,900
Arkansas	78,700	74,826	75,150	76,750
Mississippi	50,000	.....	53,300	94,250
Illinois	262,300	.....	288,500	317,550
Indiana	16,500	.....	14,100	19,350
Eastern (Not incl. Ill. & Ind.)	115,000	.....	100,500	96,800
Michigan	63,700	.....	57,500	45,900
Wyoming	92,500	.....	90,550	91,000
Montana	23,400	.....	21,950	21,400
Colorado	7,000	.....	6,550	5,600
New Mexico	105,800	105,800	96,600	92,800
TOTAL EAST OF CALIF.	3,370,100	.....	3,091,850	3,236,850
California	823,700	823,700	781,200	583,000
TOTAL U. S.	4,193,800	.....	3,873,050	3,819,850

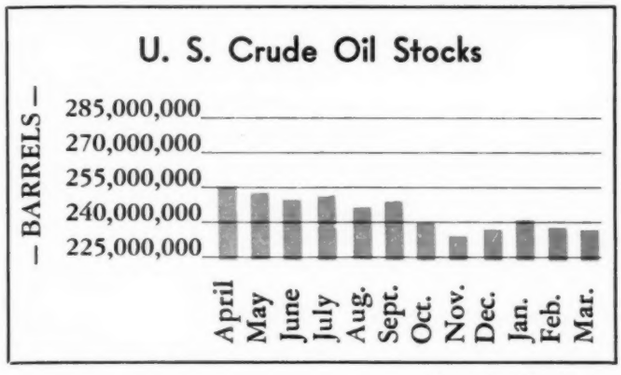
[1]P.A.W. recommendations and state allowables represent the production of all petroleum liquids, including crude oil, condensate and natural gas derivatives recovered from oil, condensate and gas fields. Past records of production indicate, however, that certain wells may be incapable of producing the allowables granted, or may be limited by pipeline proration. Actual state production would, under such conditions, prove to be less than the allowables. The Bureau of Mines reported the daily average production of natural gasoline and allied products in December, 1942, as follows: Oklahoma, 29,600; Kansas, 5,900; Texas, 107,400; Louisiana, 21,500; Arkansas, 2,700; Illinois, 10,200; Eastern (not including Illinois and Indiana), 12,600; Michigan, 100; Wyoming, 2,500; Montana, 400; New Mexico, 5,700; California, 43,900.

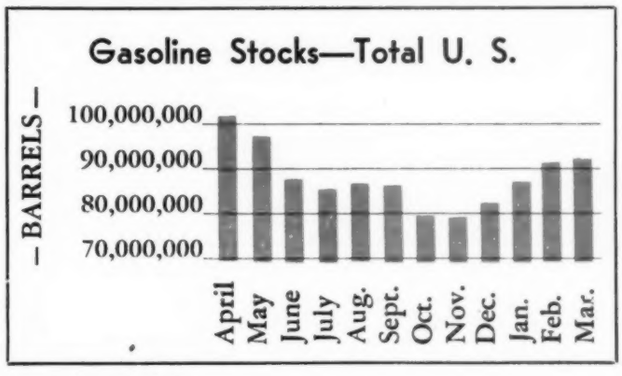
[2]Oklahoma, Kansas, Nebraska, Mississippi, Indiana figures are for week ended 7 a. m., March 24.

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for March, 1943

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
Eastern Texas	28	23	6	....	3500-3700	2	40	Rotary
Gaines County	3	2	5	....	4400-5584	2	22-35	Rotary
Hockley County	5	3	3	....	4800-6850	2	20-30	Rotary
Ector County	3	2	5	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	20	15	4	....	1700-3900	2	40	Rot.-Cab.
Nueces County	5	4	6	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	5	3	4	....	3730-2935	2	42-43	Rot.-Cab.
Hawkins Field	7	6	4	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	4	2	6	3	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	10	7	5	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	7	5	5	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	6	4	3	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	153	112	66	138	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	15	12	6	3	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	4	2	5	2	1840-11,450	3 or 4	14-30	Rotary
Wilmington County	5	4	4	2	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for March, 1943

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1942 (In Barrels)
	March	February	March	February	March	February	March	February	March	February	
Arkansas	21	12	11	8	20	8	8	3	17	7	26,560,000
California	86	62	69	46	15	16	28	21	35	26	248,250,000
Illinois	153	159	112	140	44	39	66	72	138	129	105,768,000
Indiana	25	23	11	20	10	22	4	4	6	8	6,680,000
Kansas	101	135	62	114	50	58	12	15	16	21	96,920,000
Kentucky	30	9	19	3	12	2	....	....	....	....	4,503,000
Louisiana	45	176	30	161	25	61	10	18	14	19	125,450,000
Michigan	31	24	13	19	7	8	9	11	3	6	21,568,000
Mississippi	2	4	1	2	....	....	....	....	....	....	27,605,000
Montana	5	8	5	6	....	....	....	....	....	....	8,998,000
Nebraska	....	2	....	1	2	3	....	....	....	....	1,367,000
New Mexico	20	32	13	29	16	25	....	....	....	....	31,875,000
New York	78*	76*	77*	66*	46	53	....	....	....	....	5,132,000
Ohio	59	51	42	44	40	38	....	....	....	....	3,480,000
Oklahoma	102	132	70	125	13	21	9	1	69	63	138,750,000
Pennsylvania	166*	114*	160*	103*	110	113	....	....	....	....	17,256,000
Texas	302	468	152	439	288	320	279	301	300	327	476,560,000
West Virginia	28	29	26	22	18	6	8	6	7	6	3,780,000
Wyoming	4	1	4	1	4	2	1	1	2	1	32,778,000
Total	1058	1517	867	1349	720	795	434	453	607	613	1,383,280,000

*Includes water-intake and pressure wells.

MAJOR *Pipe Line* ACTIVITIES

BATTLING spring mud in the valleys and late snow in the mountains, construction crews on the 24-in. War Emergency Pipleline had crossed the 200-mile mark on the 809-mile march from Illinois to New York and Philadelphia, Petroleum Administrator for War Harold L. Ickes announced early this month.

Ickes said:

"Actual pipe-laying is now in progress on all of the 17 working spreads into which the work has been divided, and with an even break on the weather during the next few weeks, the 'Big-Inch' will roll into its refinery terminals at New York and Philadelphia on schedule."

According to reports from construction headquarters of War Emergency Pipelines, Inc., builders of the pipe line for the government, heavy rainfall over the entire route of the eastern extension of the line has severely hampered recent operations. Numerous rivers as well as small streams have been at flood stage, making work on adjacent lands impossible.

Despite winter weather difficulties that delayed the beginning of construction on several of the contract sections, current construction progress is satisfactory, according to Deputy Administrator Ralph K. Davies.

Davies said:

"Reports from the 'Big-Inch' working gangs are materially more encouraging now than they have been throughout the winter. Alternate storms and thaws along the route of the pipe line have created impossible working conditions for both workmen and machines for extended periods, but the construction pace is now advancing, and improved conditions along the right-of-way will soon make it possible for the construction gangs to 'catch-up' on much of the time lost during February and early March."

The "Big-Inch" completion schedule calls for oil to be flowing into the eastern refineries and storage terminals by early summer. Capacity operation at a rate of 300,000 bbl. a day is expected shortly after the beginning of full Texas-East Coast pumping operations. Twenty-five stations will pump a continuous stream of oil over the 1340 mile route. (Actual mileage of the pipe line, previously reported to be 1385 miles, has been reduced during construction by an overall straightening of the route by the procuring of more favorable right-of-way.)

Now in operation between the Longview, Texas, and a temporary tank car trans-shipment terminal at Norris City, Illinois, the War Emergency Pipeline is already contributing markedly to the increasing overland flow of petroleum to the eastern seaboard. Officials of the Petroleum Administration have reiterated the warning, however, that there is still no assurance that civilian supplies of gasoline and heating oil will be more ample next winter than they were during the past winter.

◆

The southernmost feeder terminal of Plantation-Bayou Pipe Line System and the 24-in. War Emergency Pipeline was placed in operation April 3 at the Pan-American Refining Corporation's plant at Texas City, Texas.

These two lines, together with the 20-in. products line originating in the Houston-Beaumont area, will be relied upon to increase supplies of crude and products for the East Coast during the year.

From Pan-American's refinery at Texas City the "Big-Inch" line will be fed No. 2 heater oil at the Longview terminal, and the Plantation-Bayou System will be fed gasoline and kerosine.

Stanolind Pipe Line Company has been giving consideration to the possible installation of a 16-in. pipe line from West Texas fields, originating at Slaughter field in Hockley County, Texas, and extending in an aproximately direct northeasterly route via the Cushing area to Drumright, Oklahoma. In addition to joining Stanolind's own main line at Drumright, this line could connect at or near Drumright or Cushing to: Texas, Texas-Empire, Shell, Empire, Gulf, Sinclair, OPL-Ajax, Magnolia, Standish, Mid-Continent, Tidewater, Continental, and Champlin lines.

The initial capacity of the 390-mile line would be 54,000 bbl. a day, which could be increased either in steps or otherwise by the addition of intermediate stations up to 116,000 bbl. a day.

A form PD-200 for this project has been prepared for submission to the Petroleum Administration for War.

◆

Authorization for extension of the 20-in. petroleum products line now under construction from the Beaumont-Houston refining area in Texas to southern Indiana, from its Indiana terminal to East Coast terminals in New York and Philadelphia, has been issued by the War Production Board, it was announced April 3 by Harold L. Ickes, Petroleum Administrator for War, who recommended several weeks ago that the line be extended to East Coast terminals.

If steel pipe for the extension of the line from Indiana to the Atlantic Seaboard is made immediately available, Ickes said, the line should be completed by the end of the year. The line was approved in January from Beaumont to southern Indiana and steel was at that time allocated by the WPB for this segment of the line. Pipe now is being delivered. The Beaumont-Indiana part of the line is due to be completed by September. From Indiana to New York and Philadelphia the line will follow the route of the 24-in. crude oil line and will be laid in the same right-of-way.

When completed to the coast the line will transport 235,000 bbl. of refined petroleum products daily, principally heating oils. It also will be available for transportation of gasoline if the demand for fuel oil does not overtax its carrying capacity.

Ickes also announced that an additional 30,000 bbl. of gasoline and other refined petroleum products daily began moving April 3 through the newly completed 179-mile extension of the Plantation pipe line between Greenboro, North Carolina, and Richmond, Virginia, destined for the East Coast rationed area.

◆

The East Ohio Gas Company is procuring right-of-way for a 120-mile, 20-in. line that will connect with the Panhandle Eastern Pipe Line Company's Detroit system near Maumee, Ohio. The line will extend from Brecksville, Ohio, where it connects with the line from West Virginia, across the northern part of Ohio.

Youngstown Sheet and Tube Company has been awarded an order for 22,500 tons of pipe for the project.

◆

A 4-in. products line from the Kanotex Refining Company's refinery at Arkansas City, Kansas, to Ponca City, Oklahoma, where it will connect with the system of the Great Lakes Pipe Line Company, is under construction and scheduled for completion by June 1.

The line, 32 miles in length, will have a capacity of 3000 to 4000 bbl. a day. One pumping station will be erected.

THE Petroleum Engineer

APRIL, 1943

Texas' Deepest Well Drilled To Depth of 14,378 Ft.

PETROLEUM ENGINEER Exclusive Feature

☆ MacDonald B-1 in Old Ocean field, Brazoria County, Upper Gulf Coast, exceeds 1939 depth record

by C. C. Pryor, Associate Editor

THE new deep drilling record for Texas and the third deepest well in the Nation has been established in the Old Ocean field of Brazoria County, Upper Gulf Coast, by J. S. Abercrombie Company and Magnolia Petroleum Company. Total depth of the well is 14,378 ft. The well is MacDonald B-1 on a 333-acre tract in the Battle, Berry, and Williams survey, six miles from Sweeney townsite, and on the western side of the field.

Passing the 13,728 ft. depth set by Union Producing Company in Brown No. 1 near Agua Dulce in Nueces County in 1939, made the well the State's deepest. At present the deepest well in the Nation is the Continental Oil Company well drilled in the Wasco area of California to 15,004 ft.

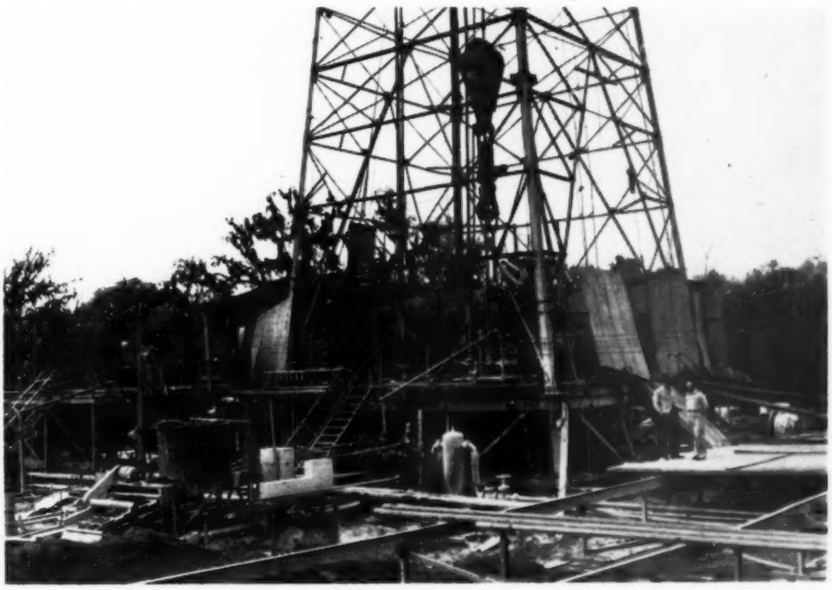
Ultimate depth of the well was scheduled for 15,250 ft., which would have topped the Nation's deepest well, however, this schedule was abandoned when the operator decided to complete in one of the several producing zones found in the well. The rig and equipment employed is capable of drilling to the scheduled depth and had been in use in the field for drilling other wells to the producing zone at about 12,000 ft.

Drill pipe, 4½-in. O.D., 16.5-lb., internal flush double grip tool joints were used to 12,709 ft. From 12,709 ft. 3½-in. O.D., 13.4-lb. full hole integral joint pipe was used to 14,378 ft., total depth of the hole.

Equipment

A 136-ft. derrick with a 10-ft. substructure was used. The drawworks employed was designed and built for deep full-hole drilling and heavy work, as well as for speed, safety, and economy. Features of the drawworks include precision high leverage brake with safety equalizer and centralized lubrication system, flame-hardened cut tooth sprockets, enclosed water-cooled brake rims, and multiple-jaw clutches on the drumshaft. The drumshaft of alloy-steel forging, heat treated, accurately machined, and mounted on heavy-duty roller bearings in self-aligning boxes is 10 in. in diameter, making it suitable for deep drilling. A 30-in. carbon steel casting drum $35\frac{5}{16}$ in. in length is grooved for 1⅛-in. wire line center preformed cable, 2500 ft. of which is used. The 40-in. hydromatic brake is mounted on the drumshaft.

General view of the J. S. Abercrombie-Magnolia Petroleum Company well MacDonald B-1 in the Old Ocean field



Low- and high-speed sprockets, made for use with No. 4 A.P.I. chain, are bronze bushed, Alemite lubricated, and have multiple 10-jaw flame-hardened clutches. Drumshaft clutches are foot operated, with controls conveniently placed at the driller's position. The lineshaft of the drawworks is 8 in. in diameter, heat-treated, and mounted on heavy-duty roller bearings in self-aligning boxes. Both ends have cathead extensions 5⅞ in. in diameter and 9¾ in. long. The jackshaft assembly, also made of alloy-steel forging, heat-treated, and mounted on heavy-duty roller bearings in self-aligning boxes, is 7½ in. in diameter, and is machined to accommodate a core reel drive. The engine drive sprocket is of the split bolted type, with the key held in place by set screws.

Speeds of the drawworks are as follows with the engine turning 250 r.p.m.; jackshaft, 263 r.p.m.; lineshaft, low 205, and high 338 r.p.m.; drumshaft (1) low, 57 r.p.m., high, 193 r.p.m. (2) low, 94 r.p.m. and

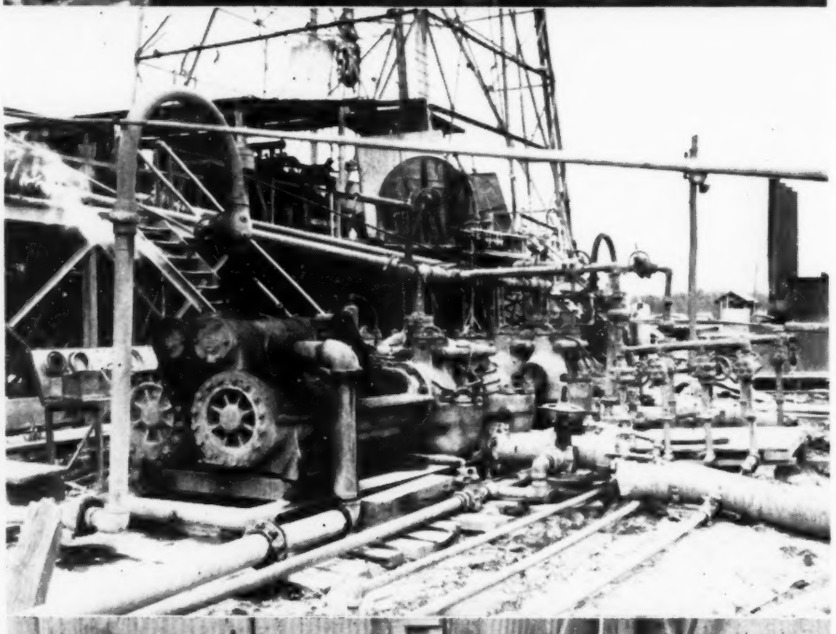
Rear view of the drawworks showing the 12-in. by 12-in. steam drawworks engine

high, 318 r.p.m. Rope speeds of the drumshaft: (1) low is 503 ft. per min. and high 1700 ft. per min., (2) low speed, 830 ft. per min. and high 2800 ft. per min.

Engines

The 12-in. by 12-in. vertical, balanced piston, valve-type, twin-cylinder steam engine mounted behind the drawworks develops 900 hp. at 300 r.p.m. and 350-lb. steam pressure and will run in either forward or reverse rotation. Operating speeds range from 50 to 400 r.p.m., although the engine can be operated safely at speeds as high as 500 r.p.m. The parts of the engine have been designed with an ample margin of safety. The engine is equipped with cut-off control for minimum steam consumption at any desired hoisting speed.

A center type drive is used with a double drive sprocket mounted on the crankshaft between the two cylinders. As reciprocating forces are transmitted vertically into the ground, excessive vibration, resulting in strains upon the engine and equipment, is eliminated, making the engine suitable for high speed and deep drilling. Less space is occupied by the vertical frame on the derrick floor and the foundation for the engine can be independent of the derrick floor. A high degree of portability is obtained by mounting the engine on two heavy reinforced, 10-in. H-beams bolted to the frame. The engine is transported in a vertical position due to the wide skid centers and low center of gravity of the engine. Each cylinder has a 2-in. fully automatic water relief valve at each end, which assures proper functioning of the valves without the necessity of a steam separator in the line. Steam is supplied through a 4-in. steam intake and exhausted through a 6-in. port. Total height of the engine is 96 in. and overall width is 58 in. Controls for the engine are mounted at the driller's position.



The main mud pumps are equipped with 20-in. fluid piston ends. The battery of boilers is shown at the right

Rotary Drive Engine

Power for the 27½-in. oilbath rotary table is supplied from a 7¾-in. by 7-in. vertical twin cylinder steam engine connected through a gear box

Rotary table, gear box, and 7¾-in. by 7-in. steam engine are mounted on the same base

Main mud pumps are in the foreground—auxiliary pumps in the background

with the complete assembly mounted on heavy unit skids. Although variable cut-off control at the driller's position permits an almost infinite number of engine speeds, the gear box permits full power of the engine to be used with two speeds, 1 to 1 and 1.54 to 1. The entire unit can be reversed quickly. The drawworks engine and drives are idle while drilling, thus considerable saving in steam consumption and wear is obtained. Much less noise is present, promoting safety on the derrick floor.

This engine was used to make two trips out of the hole when mechanical difficulty was encountered with the main drawworks engine. Although it was reported that the two trips out of the hole, once with 9000 ft. and once with 11,000 ft. of 4½-in., 16.5-lb. drill pipe were slow, the trips were made without trouble. Connection of the rotary engine to the drawworks was made possible by the design of both the drawworks and the engine. The rotary engine is equipped with a sprocket on the shaft immediately past

Shale shaker and mud-testing equipment seen from mud pits

the gear box. A chain coupling between the sprocket on the engine side and the sprocket on the rotary table side was disconnected and the engine sprocket and drive sprocket on the drawworks connected. The slow speed of the drawworks was due to the difference in sizes of the sprockets on the engine and drawworks. The rotary table can also be operated from the drawworks if required.

Employing the separate engine for the rotary table promotes a saving in operating time as well as rigging-up and tearing down time. It is also useful as a standby drawworks in case of breakdown. Both the rotary table and the engine are mounted on the same base and are easily skidded to drill the

Bit record

Number	*Size, in.*	*Type*	*Footage*	*Average, ft.*
2	18	4-way	2,227	1,113
15	12¾	4-way	2,812	187
1	12¾	2-way	185	185
11	12¾	Rock	3,692	336
48	8⅝	Rock	3,577	74
2	8⅝	Rock	132	66
50	6	Rock	1,635	33

Three boiler feed water pumps 10-in. by 4½-in. by 10-in. supply the battery of four 125-hp. boilers

rathole and to make and break tool joints on round trips with the pipe, which is a time-saving operation.

Horsepower of the engine is 310 at 400 r.p.m. It can be used at speeds as high as 700 r.p.m. Rotary speeds are controlled by a forward neutral, and reverse lever and throttle-valve remote control at the driller's stand.

Mud Pumps

Mud pumps for the rig consist of one 18-in. by 6-in. by 20-in. fluid piston pump and one 15-in. by 6-in. by 20-in. fluid piston pump. The two auxiliary pumps, also used for mud mixing, consist of one 15-in. by 7-in. by 18-in. and one 16-in. by 7-in. by 18-in. The pumps have side suction connections on each side of the pumps.

Drilling mud

Depth in ft.	*Mud weight*	*Viscosity*	*Pump pressure lb. per sq. in*
8,700	9.8	50	1000
9,000	10.4	50	1200
10,300	10.8	52	1200
10,400	11.1	55	1250
10,500	11.7	60	1250
11,000	12.0	60	1300
11,300	12.2	55	1300
11,600	12.9	60	1300
12,000	13.4	48	1350
12,200	13.8	48	1350
12,500	14.2	52	1400
12,800	14.9	45	1650
12,900	15.1	62	1650
13,300	15.9	68	1800
13,400	16.1	60	1800
14,364	16.4	64	2500
14,368	16.8	67	2500
14,378	17.0	60	2500

Log of operations

Date	*Depth, ft.*	*Operation*
8/28/42	0	Started rigging up
9/ 3/42	45	Spudded and set 20-in. conductor pipe at 45 ft.
9/ 5/42	45	Drilled plug
9/ 8/42	2,227	Set 13⅜-in. 54.15 lb. casing at 2,227 ft. with 500 sacks of cement
9/11/42	2,227	Drilled plug
10/31/42	8,916	Set 9⅝-in. 38.93 lb. casing at 8,916 ft. with 1,000 sacks of cement
11/ 4/42	8,916	Tested pipe
11/ 5/42	8,916	Drilled plug
1/ 2/43	12,709	Set 7-in. 30 lb. and 27.73 lb. oil string at 12,709 ft. with 1,200 sacks of cement
1/ 5/43	12,709	Laid down 4½-in. drill pipe
1/ 9/43	12,709	Picked up 3½-in. drill pipe
1/10/43	12,709	Tested casing
1/11/43	12,709	Drilled plug
3/ 9/43	14,378	Reached total depth of well

Casing program

Item	*Length in ft.*	*Description*
Conductor pipe	45	20-in., 48-lb.
Surface casing	2,227	13⅜-in., 54.5-lb. set with 500 sacks of cement
Protection casing	8,916	9⅝-in., 38.93-lb., flush joint threads, set with 1,000 sacks of cement
Oil string	12,709	7-in., set with 1,200 sacks of cement
		6,008 ft., 29-lb., extreme line
		3 ft., 29-lb., combination joint
		2,367 ft., 30-lb., external upset end Speedtite
		43 ft., 30-lb., combination joint
		4,298 ft., 27.73-lb., flush joint threads

Boilers and Pumps

Steam for the drilling engine, rotary table engine, and the four slush pumps is supplied by a battery of four 125-hp., 350-lb. working pressure boilers. Natural gas is used as fuel and is obtained from other wells in the field. Mounted with three boiler feedwater pumps and a reserve water tank on a platform several feet above the ground and about 50 yards from the derrick, the battery is reached by board walks from the derrick due to conditions imposed by heavy rains.

The feedwater pumps are 10-in. by 4½-in. by 10-in. steam-driven reciprocating pumps.

The blowout preventer was a 6000-lb. preventer with master valve and flowline valve.

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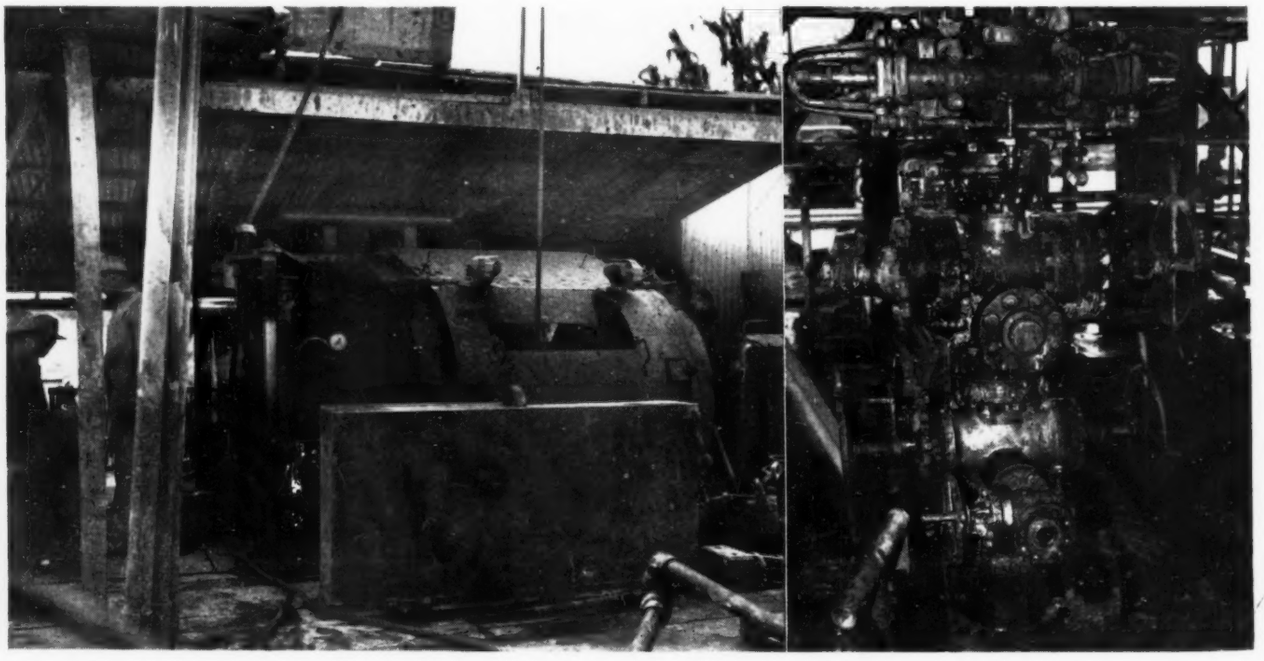
Drawworks of the rig (left) has 35-5/16-in. length drum, 30-in. in diameter. At right is shown the blowout preventer of the well



Making Repairs To Loaded Pipe Lines

☆ Latest accepted procedure permits repairing of leaks efficiently and with maximum safety while line is in operation—simple calculations set-up

PETROLEUM ENGINEER Exclusive Feature

by William T. Pyott

Corrosion Engineer, Great Lakes Pipe Line Company

THE former practice of removing corroded sections from pipe lines had become entirely obsolete somewhat prior to the present emergency. The vast expansion of product lines and the already over-burdened crude oil lines, of necessity, had to be repaired with the minimum of enforced down time resulting in irretrievably lost capacity as well as product spill. At one time, the following procedure was common among many operating pipe lines. With the discovery of the first leak at a given location, a saddle clamp was installed. When the second leak appeared, the line in the vicinity was uncovered, raised, and inspected to determine what expanse should be removed. After taking suction on the line and closing any gate valves situated advantageously, the line was parted. Feeble efforts were made to salvage some of the oil. The remainder soaked into the ground, ran down waterways, or otherwise polluted the countryside. The open ends of the pipe were mudded off, and the new pipe section welded directly into the line. The mud slug was then pumped down the line where it promptly fouled up strainers, pumps, and packing and in general seriously interfered with normal operations.

Improvements

Various minor improvements emanated from time to time. The development of a packer that could be slipped into the open ends of the pipe and allow the recoupling with welding flanges eliminated much danger and all of the mud. This mud had proved especially grievous in gasoline pipe lines, where it often made its way to loading terminals and was pumped into tank cars. Sealing plug scrapers are of great value in eliminating or materially reducing the usual spill, but their use is now indicated only in those cases where line must be parted to make major piping changes, elevate or move lines, etc. Another type of plug used on crude lines consists of a slug of asphalt pumped into the line at each end of the proposed cut. The asphalt is solidified by freezing with dry ice. When normal pumping can be resumed, the plug is heated to the softening point and pumped ahead. Such a plug cannot be used in product lines because of contamination by the dissolved asphalt. Concrete plugs constitute another method of removing pipe. In this instance, a portable pump is used to move product down the line, so that a "dry cut" is made and the concrete may be removed. In case two parallel lines are operated carrying the same product, it is often possible to pump from one line to another and thus obtain a "dry cut." It was not until the use of electric welding became prevalent that the actual repair of loaded and operating lines became possible. In the hands of capable and experienced welders, half-soling and pit welding of loaded lines became common practice.

WILLIAM T. PYOTT

graduated from Yale University in 1933 and from Oklahoma University in 1935 with masters degree in refining—Entered employ of Great Lakes Pipe Line Company, Kansas City, Missouri, in 1935 as corrosion engineer—His work is on corrosion problems, external and internal, of gasoline lines; also construction and design of new facilities.

Line Pressure Important

One of the first problems in connection with live-line welding was the determination of the proper line pressure to maintain at the point in question. To

some extent, it was practice to interrupt pumping and repair the line while dead. This procedure rapidly became obsolete, as the attendant danger and hazards were immediately recognized. An idle line is apt to contain air pockets or they can be generated by the welding heat. In case the welder were to burn through the pipe wall into such a gaseous space, a serious fire and explosion were possible. It was readily apparent, therefore, that fluid must be in continuous movement through the line. The question then arose regarding what pressure should be present at the welding point. It was recognized that a full line pressure would render pit filling a hazardous procedure because of possible ruptures. This would mean the use of half-sole material only, which was a needlessly costly operation. There also arose the problem of the maximum depth of corrosion pit that could be filled directly by weld metal. Actual hydraulic tests on pipe sections revealed that pits half way through the pipe wall could be welded safely, provided the hydraulic pressure did not exceed 300 lb.

As a further precautionary measure, no pits, regardless of depth, were to be filled on the bottom half of the pipe. This procedure was for the protection of the welder in case of burn-throughs, so that he would have ample space to avoid any flames. As a maximum pressure of 300 lb. was designated at the weld location, it was necessary to devise some method whereby this pressure could be checked. The obvious procedure, of course, would be to make a tap into the line and connect a pressure gauge. The upstream station would then adjust its pump speed until the required 300 lb. maximum existed. In case the location was such that the pressure with normal station operation was less than the maximum, no adjustment was required.

Several objections are obvious in connection with this method. An accurate pressure gauge is essential. Such a gauge when carried on a maintenance gang truck would of necessity be short lived or often inaccurate because of jolting and rough handling. There would be considerable difficulty in adjusting the station operation to the pressure required unless a telephone system were immediately available for checking. It would be necessary to make a rough calculation of the pressure to be expected based upon some fixed value at the impulse station, and then determine the exact value by slowing down or speeding up the pumps as required. Of course, as a maximum pressure of 300 lb. is allowable at the weld, it might be possible to run the upstream station at this arbitrary figure and assume that friction loss in the line would keep the pressure figure at the repair site below this value. There are two objections to this method. In the first place, one of the purposes of live-line welding would be partially defeated; that is, the line capacity would be so greatly reduced in many instances that the volume moved would be only a fraction of full pressure volume, in most instances a needless result. In the second place, variations in topography and elevations might result in a greater pressure than 300 lb. at the weld location although the pumping pressure at the initial station were held to this figure. For this reason, it is not possible to calculate the pressure at any point on the line by assuming that it is inversely proportional to the distance from the initial station. This assumption is true provided the line is practically flat or free from any substantial profile variations.

Calculating Pressure

It is possible to calculate the pressure required at the upstream station in order to produce exactly 300 lb. at the weld. Five factors must be known: the distance between stations, the distance from the weld site to the downstream station, and the elevations of both stations and the repair site.

E_1 = elevation of initial station,
E_2 = elevation of terminal station,
E_3 = elevation of proposed weld,
L = total length station-to-station,
L_1 = length from weld to terminal station, and
P = pressure at initial station to produce 300 lb. at weld.

Then for gasoline:

$$P = \left(\frac{300 + ([E_3 - E_2]\,0.32)}{L_1} \times L \right) + \left([E_2 - E_1] \times 0.32 \right)$$

As an example, assume that the two stations are 50 miles apart, with the proposed weld to be 20 miles from the downstream station. The elevations are as follows: Initial station, 800 ft., terminal station, 1000 ft., and weld site, 700 ft. By substitution in the above formula $P = 574$ lb. per sq. in. In case it is assumed that the pressure is inversely proportional to the distance, $P = 750$ lb. per sq. in. As a result, a dangerous pressure would actually exist at the weld site, considerably in excess of the 300 lb. maximum. Another example is as follows: Assume distances as the same as before, but $E_1 = 700$ ft., $E_2 = 800$ ft., $E_3 = 1000$ ft., then $P = 942$ lb. per sq. in. As before, by assuming pressures proportional to distance, $P = 750$ lb. per sq. in. Of course, the safety in operating the initial station at 750 lb. would be no item but substantial gallonage movement would be lost because of operating some 200 lb. below that which could be safely applied.

Safety Rules

In all loaded line repair work, there are certain safety rules that must be promulgated and in turn rigorously enforced. Among these are the following:

1. No pits shall be filled that are more than half way through the pipe wall. Determinations shall be from measurements made with a pit gauge and information regarding pipe weight. In no event shall any pits, regardless of depth, be filled on the bottom half of the pipe. Use a small plate or short length of half-sole material.
2. A carbon dioxide fire extinguisher shall be available at the welding site at all times.
3. In case of doubt regarding condition of pipe, use full housing rather than half soling.
4. All welds must be tested with air and soapsuds before being pronounced satisfactory.
5. Welder helpers and all employees within the vicinity of the arc shall wear protective goggles while welding is in progress.
6. Equipment present near the welding must be kept at a minimum. It should be situated up wind from the weld. The number of employees working near the weld should be small. Usually the welder and his helper are sufficient.

It is of the utmost importance to be certain that the upstream station is operating continuously while work is in progress. In case this station must shut down because of an emergency, the welding gang should be advised. In case the company telephone line is at hand, a field telephone with a selector provides means of communication. If the telephone line is some distance away, it is necessary to keep a man at the closest point on the telephone constantly to advise of shut downs. This man can be provided with a car or if possible a wig-wagging signal system may be utilized. In case there is no telephone line, a pressure gauge must be attached to the line and constantly watched. It is extremely unlikely that hill pressure alone would produce 300 lb. at the welding site, but in mountainous country this fact must be considered, as a shut down would not be apparent from pressure gauge readings alone.

The testing of welds with air and soapsuds is necessary regardless of the skill or experience of the welder. Pin holes are found more often in the corner welds of half-sole material. The testing may be done with a small bicycle pump, after welding a valve into the plate. It is, of course, extremely important that all welds be absolutely free of pinholes, as any leak will destroy the effectiveness of the work.

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One of the large pumps on test in the manufacturer's laboratory

PETROLEUM ENGINEER EXCLUSIVE Feature

by

Frank H. Love

Managing Editor

Pumping Equipment on World's Largest Diameter Oil Line

☆ Specially designed pumps and motors required to obtain line's rated capacity of 300,000 bbl. a day

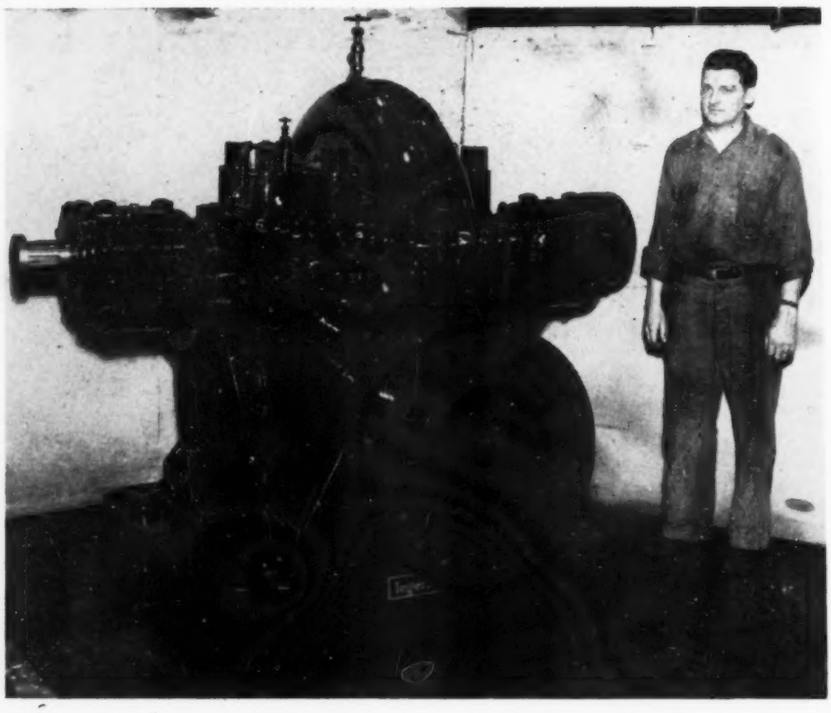
PUMPING equipment installed on the world's largest diameter oil pipe line, the 24-in. carrier of War Emergency Pipelines, Inc., is of special design for this specific application. The arrangement of three pumps in series at each station represents a departure from usual pipe-line practice, which customarily employs multi-stage pumps. The pumping units are single-stage, high-head centrifugal pumps direct-coupled to 1500-hp. motors.

Full-voltage starting equipment

Each pump has a rating of 8750 gal. per min., operating against a total head of approximately 660 ft., and is driven at a speed of 1785 r.p.m. Suction pressure is approximately 30 lb. and discharge pressure 725 lb. Design of the pumps permits all three to operate in series; two may operate in series, or one pump may operate alone, depending on the arrangement that is most desirable. When three pumps are operated in series to obtain the line's rated capacity of 300,000 bbl. a day, the total head is approximately 725 lb. per sq. in. When two pumps operate in series the line will deliver about 80 percent of its rated capacity, and with one pump operating the line will deliver about 55 percent of its rated capacity. Due to the topography of the line some of the pumps have slightly different heads than stated.

So that all pumps would be interchangeable and all station buildings uniform in size, the two manufacturers[1]

[1]Ingersoll-Rand Company and Allis-Chalmers Manufacturing Company.



Size of the centrifugal pumps can be seen in this photograph showing workman standing beside one of the units

agreed on all principal dimensions. The pumps are thus interchangeable on their baseplates, and all stuffing boxes, coupling guards, etc., are interchangeable, which has enabled War Emergency Pipeline engineers to use one set of plans throughout, and also makes possible the shifting of pumps to various locations in the event of emergency.

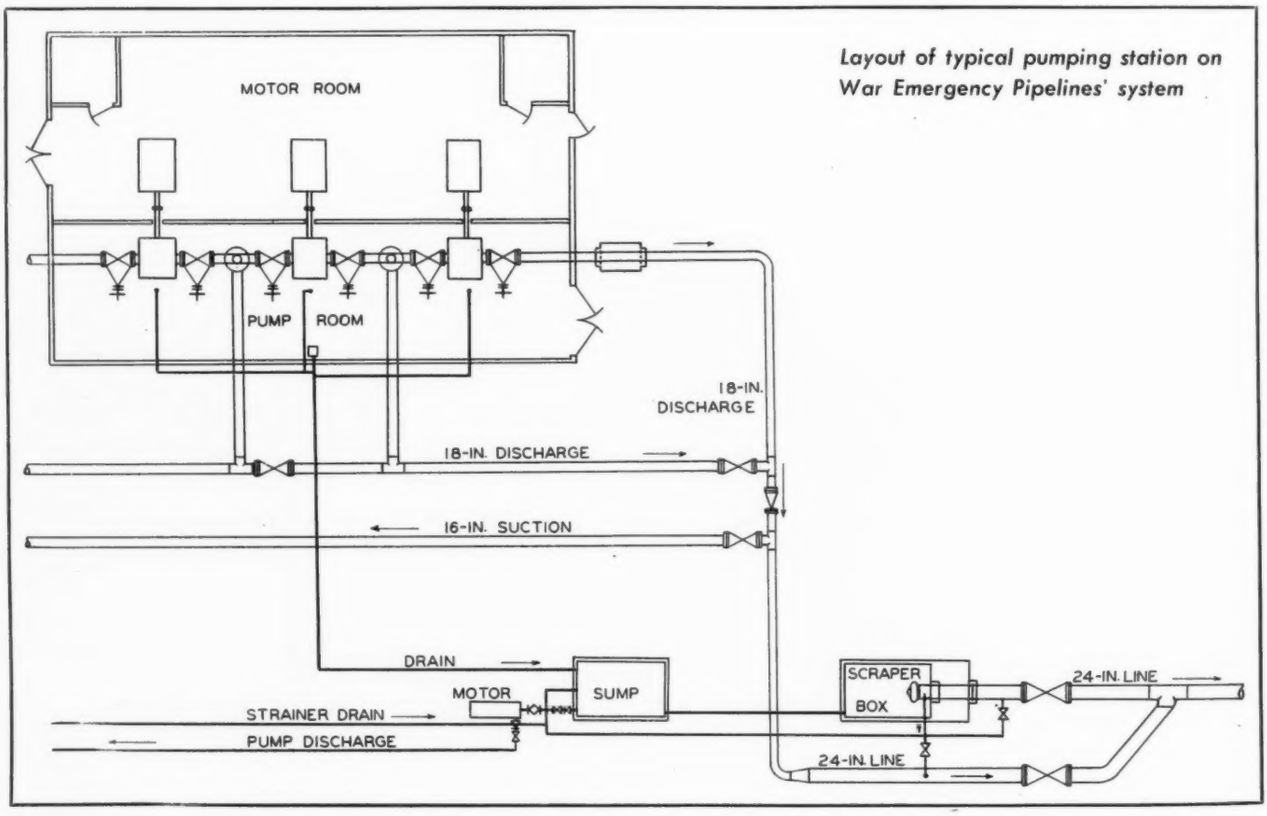
At the request of the War Production Board, scarce materials were used in minimum quantities in the manufacture of the pumps. Instead of cast-steel casings, which ordinarily would have been employed, a high-grade cast-iron was used. The impellers are of high-test cast-iron whereas normal practice would have been to use bronze. Cast-iron also was used for the baseplates instead of fabricated steel. Only a small amount of bronze was used for wearing rings and bushings.

Prime Movers

As with the pumps, the motors, which are of two makes,[2] are designed for interchangeability. As the motors are designed with a 18-in. shaft extension that passes through the firewall and is direct-connected by a flexible coupling to the pump, a common base is not provided for motor and pump, but the motors are supplied with special sole plates, the design of which was standardized for this project. The motor shaft extends through a stuffing box in the firewall for the purpose of sealing the opening to prevent passage of hazardous gases from the pump room to the motor room.

Each motor is rated 1500 hp. at 2300 volts for 3-phase, 60-cycle service and is designed for a synchronous speed of 1800 r.p.m. and has a full-load speed of approximately 1785 r.p.m. They are of the open squirrel-cage type and are self-ventilated by fans built integrally with the motor. Air enters the motor at

[2]Westinghouse Electric and Manufacturing Company and General Electric Company.



Layout of typical pumping station on War Emergency Pipelines' system

Three of the 1500-hp. motors on their way out the delivery door of the manufacturer

each end bracket and is expelled through an opening in the top of the motor frame. This design is somewhat unusual, as normally this type of motor discharges the air downward from each side. The object of the upward air discharge is to direct the air into ducts of the station ventilation system and avoid the possibility of recirculating hot air through the motors. This would be particularly serious for the middle motor, which might draw hot air from the motor on either side; also, by placing the station air ducts above each motor instead of between them, they are out of the way and permit more convenient operation and inspection of the motors. An exhaust fan driven by a 1-hp. motor is situated in the ventilating duct mounted over each motor. When it is considered that the air discharge from three 1500-hp. motors running under full load carries energy in the form of heat equivalent to approximately 225 hp., ventilation is obviously necessary in the stations to keep the motor room comfortable at all times.

Although in some of the pumping stations the motors will be started by the reduced-voltage method and in others by the full-voltage method, all motors are designed for full-voltage starting and may thus be used with either type of starting equipment.

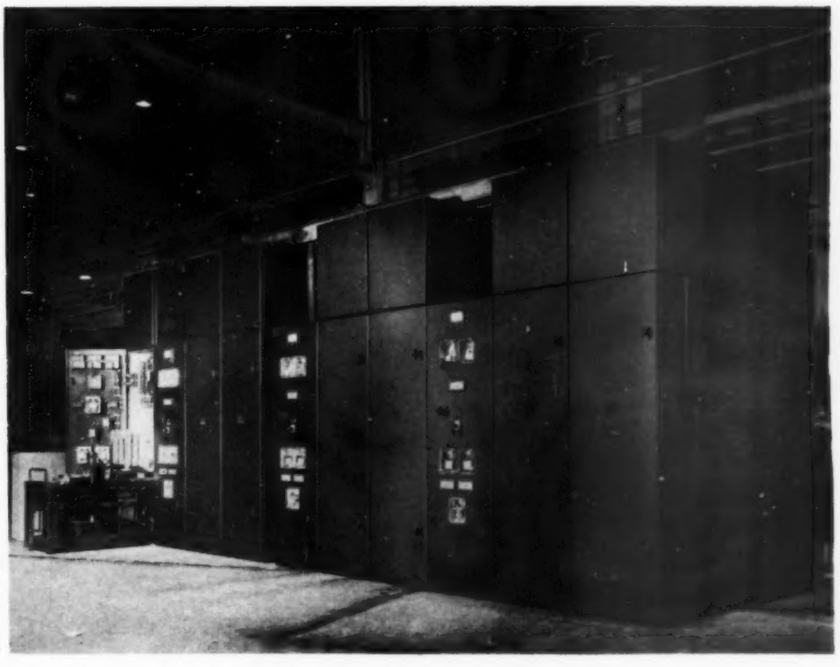
The mainline motors are the largest so far built for pipe-line service. Each weighs about 5½ tons and is approximately 4½ ft. high by 4½ ft. wide. The overall length, including the 18-in. extended shaft, is slightly more than 7 ft.

In addition to the main motors, at the Norris City terminal there are two 250-hp., 1800-r.p.m. motors driving loading rack pumps, two 350-hp., 3600-r.p.m. motors driving delivery pumps, and three 100-hp., 1800-r.p.m. motors driving suction booster pumps. The 100-hp. motors drive the pumps that take oil from the tank farm and feed it into the main line pumps on the eastern extension of the line. All these motors are of the standard open-type with sole plates, and, except for the 350-hp. motors, have 18-in. shaft extensions through a firewall. Because of the problem of critical speed, it was not practicable to use an 18-in. shaft extension with a coupling on the outer end on the 350-hp. motors, but this difficulty was overcome by providing the motors with a standard short shaft and interposing a floating shaft between the motor and the pump. This passes through the firewall and is equipped with a flexible coupling on each side of the wall.

Southern Terminal

The southern terminal of the line at Longview, Texas, is fed by several smaller pipe lines, and here a tank farm has been built to provide ample storage capacity. The oil is pumped from the storage tanks by three single-stage centrifugal pumps each rated at 110,000 bbl. per day against a head of 40-lb. pressure. These pumps operate in parallel, pumping directly into the suction of the main pipe-line pumps, providing at all times a minimum pressure of 20 lb. on the suction. The piping is also arranged so that the main pump can, if necessary, take suction directly from the tanks or from the incoming pipe lines.

(Continued on Page 44)



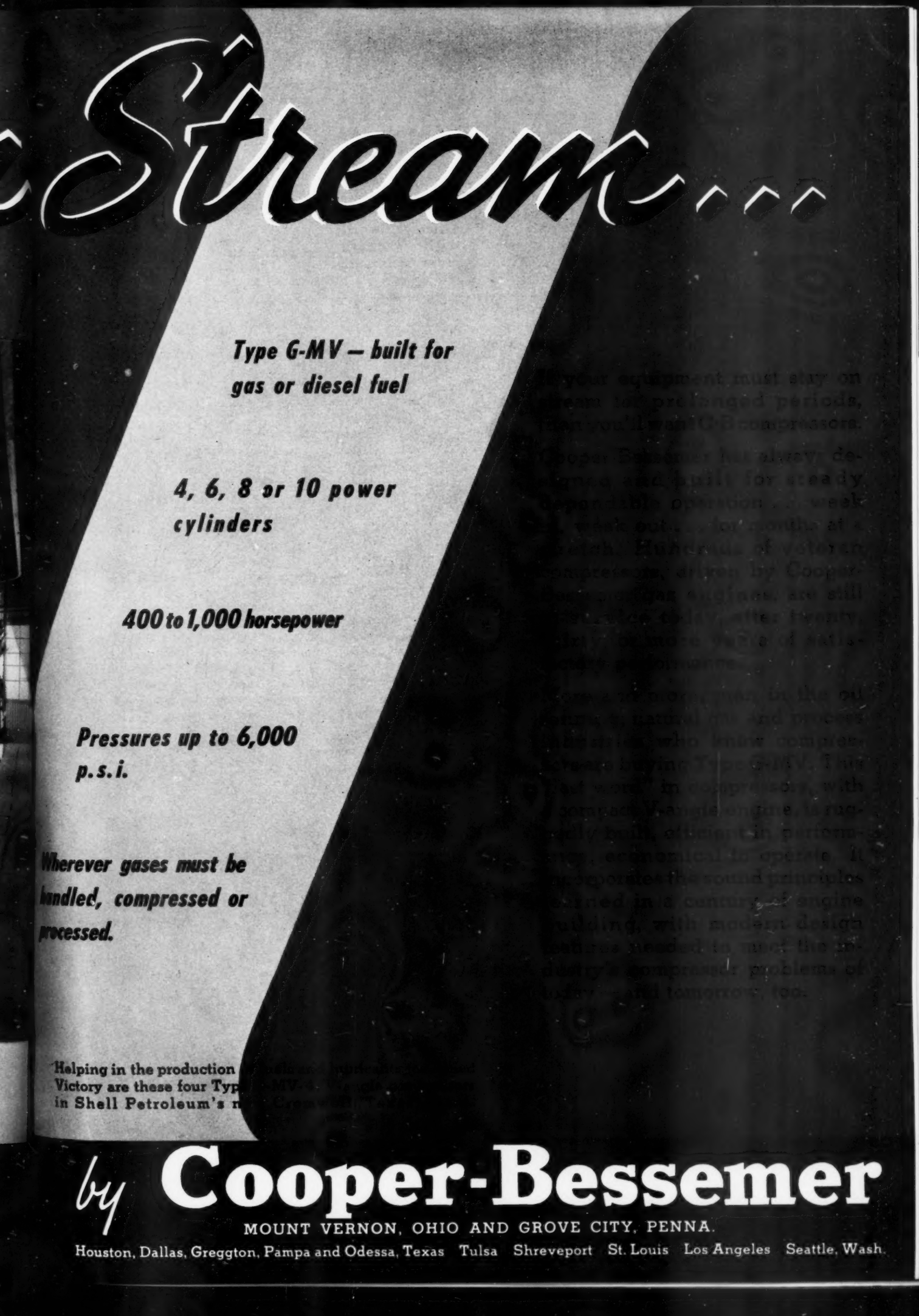
Switchgear equipment for control of a 2400-volt incoming line and reduced voltage starting of three 1500-hp. induction motors

Longer on

TYPE G·MV ANGLE

Compressor

New York Washington Bradford, Pa. Parkersburg, W. Va. Gloucester, Mass.


Stream...
Type G-MV — built for gas or diesel fuel
4, 6, 8 or 10 power cylinders
400 to 1,000 horsepower
Pressures up to 6,000 p.s.i.
Wherever gases must be handled, compressed or processed.
Helping in the production
Victory are these four Typ
in Shell Petroleum's
by Cooper-Bessemer
MOUNT VERNON, OHIO AND GROVE CITY, PENNA.
Houston, Dallas, Greggton, Pampa and Odessa, Texas Tulsa Shreveport St. Louis Los Angeles Seattle, Wash.

(Continued from Page 41)

Starting the Main Pumps

In starting the main pumps at the initial station, it was necessary to work out quite carefully the sequence of starting in order to get the units on the line in the shortest possible time and to eliminate the opening and closing of unnecessary valves, as it was decided to use only manually operated valves to conserve as much material as possible and reduce the initial installation cost. All three of the main pumps were brought on the line in about one minute's time. This was done by opening wide the suction and discharge valves on pumps Nos. 1 and 2 and the suction valve on pump No. 3, leaving the discharge valve on the third pump barely cracked. The booster pumps were then started and pumps Nos. 3, 2, and 1 started in quick succession, after which the main discharge valve on pump No. 3 was gradually opened to deliver oil up the line. This arrangement left only the one valve to operate after starting the units and also kept the running time of the pumps against closed discharge valves at a minimum, as well as enabling all motors to be started with a minimum load. The discharge valve of the third pump was throttled sufficiently to maintain line pressure.

☆ ☆ ☆

P 686.4

Mass Spectrometer Analysis of Gasoline

IN a closely guarded laboratory in the heart of a Philadelphia oil refinery, physicists have achieved a new triumph in the application of electronics to the war effort. The achievement is the industrial use of an amazing instrument, the mass spectrometer.

The research organizations of The Atlantic Refining Company at Philadelphia, and of the Consolidated Engineering Corporation at Pasadena, California, have coöperated to bring to practical use for the first time in any industry this device, which will greatly expedite a critical part of the war program—the manufacture of aviation gasoline.

This development makes possible a marked improvement in the analysis of gases used in making high octane aviation gasoline and synthetic rubber stocks, and opens the door to unlimited research in these fields. In addition to improving present production methods, it is expected that the mass spectrometer may pave the way for entirely new gasolines.

The Consolidated Engineering Corporation had the vision to recognize the dormant possibilities of a mass spectrometer as well as the skill and patience to solve a multitude of problems in design, manufacture, and precision operation. It was while investigating the possibilities of soil analysis in discovering oil deposits that the Research Department of The Atlantic Refining Company first became associated with the Consolidated Engineering Corporation.

As a consequence of their extensive activity in the war effort, Atlantic research scientists promptly saw the many practical applications made possible by Consolidated Engineering Corporation's development, and persuaded the latter company to build a mass spectrometer for use in aviation gasoline and other strategic programs.

The use of the mass spectrometer permits analysis of some gases that cannot be separated by distillation procedure. Such extension of the ability to determine hydrocarbons in gasoline may lead to the development of better, or even new gasolines.

The new method is eight times as rapid as the old, it is asserted. This results in closer control of plant operations, because rapid analysis of samples permits much more frequent testing and checking of plant equipment.

In the old method, the care used by the analyst was an important factor, and because of the human element, the results often varied greatly. The mass spectrometer eliminates this variable.

To make tests and check tests, the past procedure required one cubic foot of gas, three-hundred-thousand times as much as is needed by the mass spectrometer.

Because of its importance to war production the instrument is now being operated under a policy that limits disclosure of its results to those engaged in the national effort to manufacture greatly increased quantities of high grade aviation fuels, and details of construction and operation are blanketed under secrecy orders. Weighing slightly more than two tons, and small enough to fit into an ordinary-sized kitchen, the mass spectrometer looks like a high-powered radio transmitter.

☆ ☆ ☆

The mass spectrometer in action at the Philadelphia refinery of The Atlantic Refining Company. Seated at the panel board is Dr. O. L. Roberts, Atlantic; standing, H. F. Wiley, Consolidated Engineering Corporation

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Cementing Through Perforations — Methods and Equipment

PETROLEUM ENGINEER Exclusive Feature

☆ The c. p. cementer used to cement casing or liner in the hole

by F. A. Graser
Consulting Petroleum Engineer

FREQUENTLY, casing or liner in the hole must be cemented through perforations or other openings in the wall of the pipe to accomplish certain results. In many cases only production equipment is available at the well for performing this work and under many conditions it is impractical to leave any cement in the well after the job is completed. Cost must often be given consideration. To meet these and other requirements, a "c.p." (cementing through perforations) cementer has been used with good results in a number of wells in some of the California oil fields.

The c.p. cementer was developed about five years ago for a specialized type of service as a result of the use of a perforation washer utilizing pressure exerted between opposed packer cups. As experience was gained, it was found that conditions under actual field operation allowed a greater range of use than was first anticipated.

The writer has had experience with the c.p. cementer almost since it was placed on the market. It was suggested that some of the types of operations that he has experienced should be described in order to acquaint others with the possibilities of the use of the tool. The uses should be divided into two general headings. The first is its substitution for more costly or more hazardous tools and methods. The second is its use for operations for which there is no suitable substitute.

This discussion is therefore presented with the object of disseminating information to those who have not had the privilege of having previously worked with this type of equipment. It should be noted throughout the number of operations to be described that they are carried out in nearly every case with production equipment at the well. The advantage gained will allow the operations to be performed at a minimum expense and without additional labor. As a result marginal wells may be saved and profits may be made on small production increases. These items are especially important during the war period.

F. A. GRASER

graduated from University of California with a B.S. degree, having majored in petroleum engineering in the College of Mining—He interrupted his college work to enter the field artillry and served 10 months in France and 8 months in Germany with the Army of Occupation during the First World War—After graduation he worked for the California State Division of Oil and Gas—In 1928 he was petroleum engineer for Petroleum Securities Company—Then spent a few months in the California Oil Umpire's office before going with the Southern California Drilling Company as field superintendent—In 1931 he opened an office as consulting petroleum engineer specializing in development work and has been in consulting work since.

Purpose of Tool

The c.p. cementer is a tool used to cement through a hole or a number of holes in a string of casing. The depth at which the cementing operations take place must by necessity be predetermined. Either one or a series of cementing operations can be carried out in rapid succession with one run of the tool. Upon conclusion of each operation, the excess cement left in the casing can be washed out and at the completion of all the operations, the tool can be withdrawn from the hole.

There are several tools that were either designed for c.p. or can be used for c.p. operations. Figs. 1 and 2 show two of the best known c.p. cementers. It is not the writer's intention to discuss the relative merits of the various tools or to enter into a dissertation on the individual methods of how each tool is operated. It should be mentioned, however, that this type of tool is similar to most of the specialty tools used in oil wells in that much of its success depends upon the operating personnel. There are certain precautions that, if observed, make the tool a safe one for oil-field work. In general, the operation of the tool is relatively simple but all conditions in the hole must be considered in connection with its use.

Description of Tool

The tool consists essentially of an outer and inner tubular assembly. It is designed with opposed packer cups, circulation passageways, and a valve. The valve affords a means of controlling and directing the flow of fluid. Accordingly, fluid can either be bypassed ahead of the cement slurry, directed out of the tool between the opposed packer cups and through the perforations, or backwashed. The spacer tube between the two sets of opposed packer cups can be varied to any desired length with the use of spacer tubes supplied with the tool, full lengths of tubing, or casing (in the largest tool size). The packer cups are specially designed to operate under high temperature and pressure.

A left-hand thread at the top of the tool is normally used and serves as a safety joint.

Field Use of Tool

Without further description, it is the intention of this article to discuss the uses of the tool in practice. As the name c.p. suggests, the tool was designed to be used for cementing through perforations. In practice, however, the tool can be used for cementing through conventional, knife, or shot hole perforations, through a hole worn in the casing, through special cementing collars previ-

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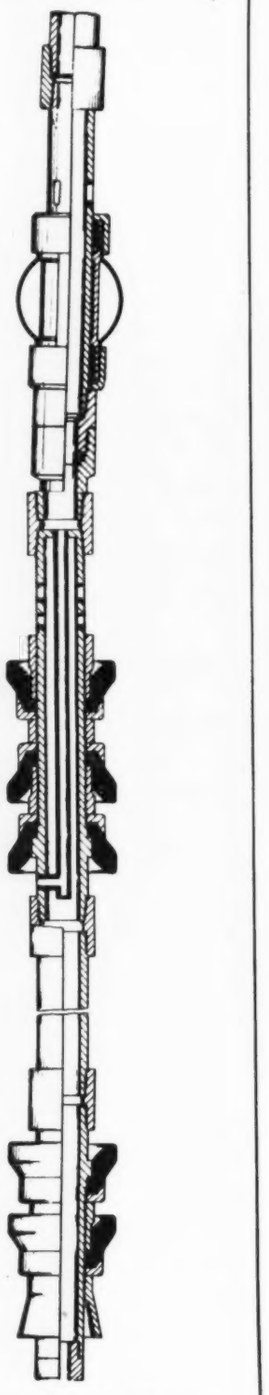


Fig. 1. The Halliburton c. p. cementer

ously inserted in the string, or through the annular space between the top of a liner and the larger string of casing through which it was inserted.

A packing-off assembly at the wellhead is necessary in order to back-wash and remove completely the cement from around the packer cups (swab rubbers). During the back-washing, the displacing fluid is pumped between the running-in string and the casing and returned through the running-in string. As the fluid enters the casing below the running-in string, it is obvious that the tool cannot be used if a low-pressure formation is open below the tool and it cannot support the column of fluid to the surface. In this case a water-tight bridge or bridging plug, below the point at which the tool is to be used, would be necessary.

It is also noted that the bypass in the tool is always open. Therefore, if a channel is open between the point of cementing and a hole or perforations below, the fluid could go out between the packing cups, pass through the channel to the hole or perforations below, re-enter the casing, pass through the bypass in the tool, and into the annular space between the running-in string and the casing. If the running-in string is packed-off to the casing at the surface the cement slurry could be forced downward under pressure through the channel to a hole below, re-enter the casing, and be forced into the open formation. It is therefore evident that the tool should be used beginning at the bottom and working upward until all operations are completed. It should also be noted that this bypass would prevent back-washing the long way if a low-pressure formation were open below the tool.

The simplest kind of job for which the c.p. cementer can be used is in the case of a hole or holes over a short interval in the water string above the shut-off. The hole or holes might be accidentally placed or intentionally placed for the purpose of testing showings, or might be due to wear or electrolysis. Any formation open below the shoe must support a column of fluid to the surface. In this case the c.p. cementer would be lowered below the holes and the tool tested against blank casing. Then the tool would be raised a small amount at a time until the holes were opposite the interval between the opposed packer cups. The tool would be raised still farther until it would clear the holes. In this way, the actual position of the holes would be situated on the running-in string. (Note: If more than one hole were present, the space between the opposed packer cups would have been increased until it was in excess of the distance between the highest and lowest of the group of holes.) Now the c.p. cementer can be lowered until the hole or group of holes is between the opposed packer cups. By moving the running-in string upward or downward, the direction of flow can be regulated and cementing operations begun. It is customary to apply a pressure using the fluid in the hole to determine the break-down pressure and the rate at which fluid can be forced away. By this means the operator can estimate the amount of cement to be used on the job. While mixing and pumping in the cement, the valve is usually positioned so that the fluid is bypassed ahead of the slurry. As the cement approaches the c.p. cementer the position of the valve is changed so that the cement goes out through the ports between the opposed packer cups. The cement is either all displaced or a maximum safe pressure is reached. The tool is lowered and the remaining cement is back-washed through the running-in string and the cementing operations are completed leaving the hole clear of cement.

One would think that the difference in hydrostatic head between the cement and the circulating fluid would cause

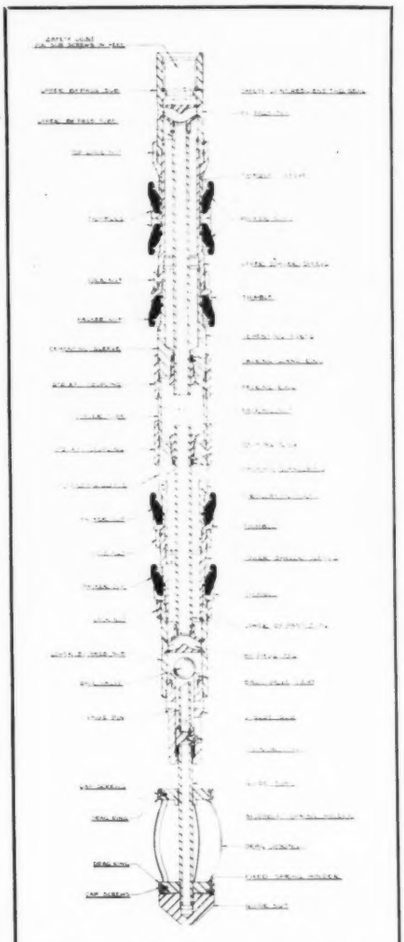


Fig. 2. Baker International c. p. removable cementer

the cement to return through the holes and re-enter the casing. This rarely occurs in practice, however. Various reasons are advanced for the failure of the cement to re-enter the casing, such as dehydration of the cement under pressure against the formation, the gel action of the cement in contact with mud in the hole, bridging of formation, and cement particles against the holes, etc.

After washing the hole clear and

"... AT THE RISK OF HIS LIFE, ABOVE AND BEYOND THE CALL OF DUTY"

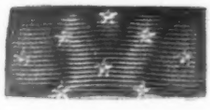
... Having lost the assistance of his teammates, interposed his plane between his ship and an advancing enemy formation of nine attacking bombers ... without hesitation, alone and unaided, repeatedly attacked this enemy formation at close range in the face of their intense fire ... shot down five and severely damaged a sixth. ...

For such gallant action, this Pilot was cited for the Navy's Medal of Honor. Authorized in 1861, this medal was originally established "to promote the efficiency of the Navy" and was restricted for enlisted men; it was not until 1915 that award of this Medal was made to include Officers of the Navy (all Medals for the Navy now are also authorized for the Marine Corps and Coast Guard).

While a new Medal of Honor was designed for and used by the Navy during the first World War, the original design is being used at the present time; it is awarded in the name of Congress (hence sometimes referred to as the Congressional Medal of Honor) to each person "who, while an officer or enlisted man ... shall, in action involving actual conflict with an enemy, distinguish himself conspicuously by gallantry and intrepidity at the risk of his life, above and beyond the call of duty."

Congressional Medal of Honor—U. S. Navy

Below: Ribbon which may be worn in lieu of the Medal



HUGHES TOOL COMPANY—Houston, Texas

moving the cementing tool to a safe position above the holes through which the cement was squeezed, sufficient time is allowed for the cement to set—usually four to six hours. In order to check the effectiveness of the job, the c.p. cementer is set with the holes between the opposed packer cups and the pressure is again applied against the holes. If the holes hold the pressure, the job is completed and the tool is removed from the well. If the holes do not hold the pressure, however, the operations are performed as before and repeated until the holes do hold the pressure.

It is conceivable that, if there were no cement around the pipe at the time of the first c.p. cementer operations, the first batch of cement would channel up one side of the casing. The additional cement jobs would break out remaining channels until all were removed and cement completely surrounded the casing. Thus it is not uncommon under such circumstances to do more than one cementing operation before the holes will withstand the pressure applied by means of the tool.

The operation as described under the simplest type of use for the c.p. cementer is the foundation for any and all uses of the tool. The only change is in the weight of the cement slurry. If the expected pressures are low and there is no chance to dehydrate the cement under pressure, the cement is usually mixed with a minimum amount of water to give a heavy slurry. This is to prevent the cement from re-entering the casing through the holes when the pressure is removed. In case of a large batch of cement, perhaps only the last part of the cement will be given a heavy mix.

Use With Special Collar

Fig. 3 shows a use for the c.p. cementer where a special cement collar was placed in a liner at 3654 ft. This type of collar had back-pressure ports that closed as soon as the cement was placed back of the liner. A basket was used below the c.p. collar in order to prevent the cement from passing downward and returning through the perforations and the bypass in the tool. The writer recommends that, for this type of operation, the tool should be run on a tail piece below the adapter or hanger with the tool a convenient distance below the cementing ports. This uses the minimum time to land or hang the liner, to test the location of the holes, and to establish circulation. (Note: Usually 5 ft. of blank casing is used between the perforations and the cement ports in order to check definitely the location of the ports.) As circulation is established immediately, the mud does not have time to gel and the cement has a better opportunity to completely surround the casing without channeling. This also reduces the hazard of cementing the perforations above the blank section. Immediately after cementing, the hole was washed clear of cement. As noted in Fig. 3, 138 sacks of cement were used in cementing. This amount was estimated to fill to about 2925 ft.

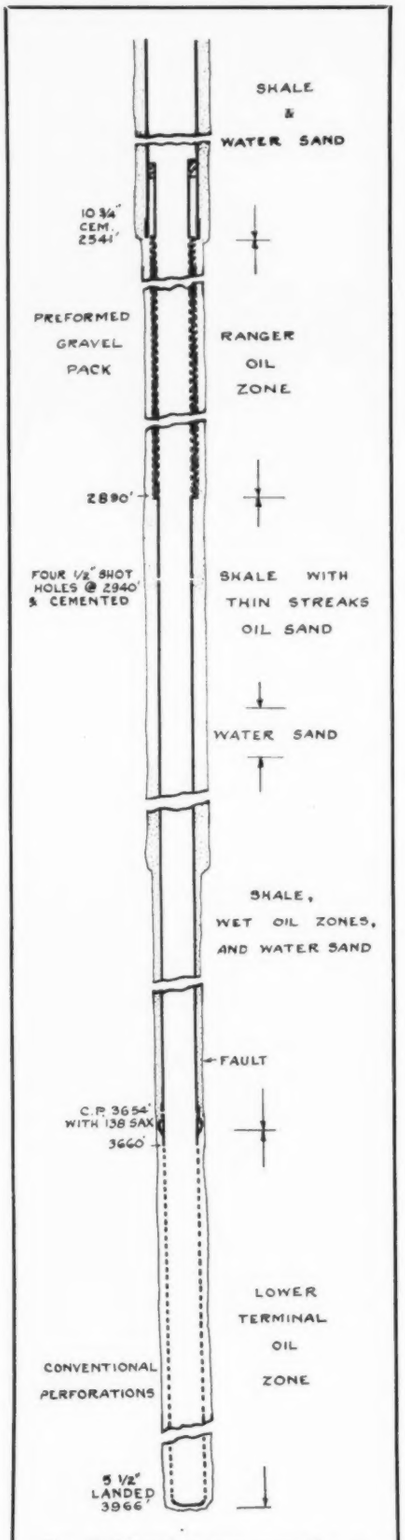


Fig. 3. Showing two uses of c. p. cementer in one well

It was the operator's intention to set a packer over the Lower Terminal zone and produce that zone only. As there were preformed gravel-packed perforations opposite the Ranger zone, the bypass in the packer set above the Lower Terminal zone was left open in order to replace the mud and water back of the tubing with oil from the Ranger zone. This would also give an opportunity to remove the mud from the perforations. Upon swabbing through the tubing, it was found that a high head of salt water was entering the hole. A water-locating run placed the point of entry at 2890 ft., or the top of the blank section. The Ranger oil zone was known to be clean so the water had to be coming from behind the blank section and the cement had not raised as high as it had been previously estimated.

Upon consulting with the superintendent and the operator, another use of the c.p. cementer was worked out whereby the water could be shut-off around the top of the blank section and yet leave the preformed gravel-packed perforations as free of cement as possible. Correlations showed that no water was present to at least 2975 ft. The 5½-in. liner was then gun-perforated with four ½-in. holes at 2940 ft., or 50 ft. below the perforations in the Ranger zone. The c.p. cementer was then used and five small batches of heavy cement were pumped through the shot holes at 2940 ft., clearing the hole of cement after each operation as previously described. The first cement could be forced away under 500 lb. and the last 10 sacks took 1500-lb. pressure. After standing a few hours, the holes stood up under 2350-lb. pressure. The well was put on production as originally intended and the water was found to be excluded from the well.

A variation of the use of the special cement collar as shown in Fig. 3 has been used in connection with the circulating type lead seal hanger. There are cases where it is necessary to bring the cement to the top of the blank section and at the same time experience shows that the hole may require more cement than that estimated from the drilled hole size. In this case an amount of cement in excess of the theoretical amount is used and displaced behind the blank section of the liner. The tool is back-washed and then immediately raised to the bottom of the gravel-wrapped perforations and there used as a washer. The mud replaces the cement and circulates the excess out of the hole. In some cases the fluid is changed to water and the entire perforated interval is washed while the cement sets behind the blank pipe.

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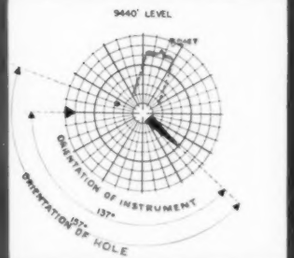

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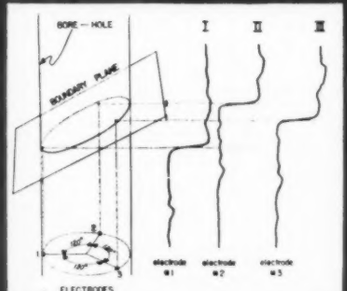

The following figures briefly outline the operations involved in a Dipmeter Survey:

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This record, which is obtained at the same time the Dipmeter is lowered into the hole, registers the drift angle of the hole, direction of drift, and orientation of the photoclinometer instrument.

Schlumberger Dipmeter Record

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Schlumberger Dip Computing Instrument

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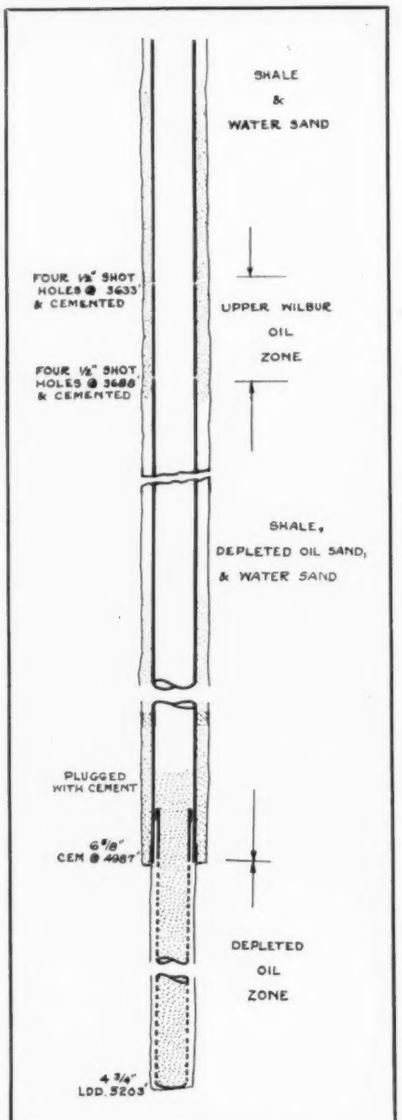
SHALE
&
WATER SAND
FOUR ½" SHOT HOLES @ 3633 & CEMENTED
UPPER WILBUR OIL ZONE
FOUR ½" SHOT HOLES @ 3688 & CEMENTED
SHALE, DEPLETED OIL SAND, & WATER SAND
PLUGGED WITH CEMENT
6⅝" CEM @ 4987'
DEPLETED OIL ZONE
4 ¾" LDD. 5203'

Fig. 4. Illustrating a use for c. p. cementer — placing cement collar around casing

Other Specific Applications

Fig. 4 shows a use for the c.p. cementer that is similar, yet quite different in certain aspects, to those previously described. This well had been completed some six years earlier at a depth of 5203 ft. The oil zone had been depleted and the well was standing idle. A good productive zone was found in adjoining wells and was located in this well by correlation. The operator decided to plug-off the old zone and perforate opposite the newly discovered zone.

The amount of cement used on the shoe of the 6⅝-in. casing was insufficient to fill back of the casing to cover this new zone unless channeling had taken place. Four holes were shot at the top of the zone at 3633 ft. to test for a shut-off. A tester on 2½-in. tubing brought out only 303 ft. of fluid consisting of water and a little oil followed by heavy mud. Four ½-in. holes were then shot at 3688 ft. to test the bottom of the zone. Water entered the hole and stood at 500 ft. from the surface.

A c.p. cementer was run on 2½-in. tubing and it was found that both sets of shot holes were open and circulation between them could easily be obtained. While circulating through the bottom holes upward behind the casing to the top holes, back into the casing, and then between the tubing and the casing to the surface, it was found that the top holes occasionally plugged with formation and it was necessary to reverse circulation to clear the holes. The tests indicated that the water above and the water immediately below the oil zone had not been cemented-off. It was therefore necessary to get the cement completely around the casing both at the bottom and at the top of the productive zone. If the cement were placed at the top first, it might be difficult to get the cement completely around the casing at the bottom of the zone. It was contemplated that, if the cement were pumped out at the bottom perforations, the cement would go upward behind the casing and most likely cement-off a portion of the annular space back of the 6⅝-in. casing the first time and then gradually cut out the channels on following cement jobs. Precautions had to be taken, however, to prevent the cement from re-entering the top holes and cementing in the 2½-in. tubing and the tool.

The c.p. cementer was set over the lower perforations and the circulation was established through the holes and the fluid returned through the upper holes and back to the surface between the tubing and the casing. One hundred sacks of cement were pumped into the tubing. When the cement and the fluid in the hole were balanced and it was estimated that the cement had reached the lower perforations, the valve on the packing-off head at the surface was closed and the cement was pumped out under a final pressure of 1200 lb.

After the casing was washed clear of cement and the c.p. cementer was pulled up from the perforations, the cement was allowed to set for about 12 hours. Because the valve on the packing-off head had been closed at the surface, the cement was kept on the outside of the casing and no cement re-entered the hole above the tool.

The holes at 3633 ft. and 3688 ft. were found to be open and the process was repeated using 100 sacks of cement. This time the final pressure was 1000 lb. No pressure was built-up on the packing-off head, showing that the upper perforations were plugged from the outside during the cementing operations. The casing was again cleared of cement and the tool raised to a safe depth.

After standing 8 hours, both top and bottom perforations were again found to be open. One hundred sacks of cement were used and 66 sacks of cement were pumped away through the lower holes at 3688 ft. The breakdown pres-

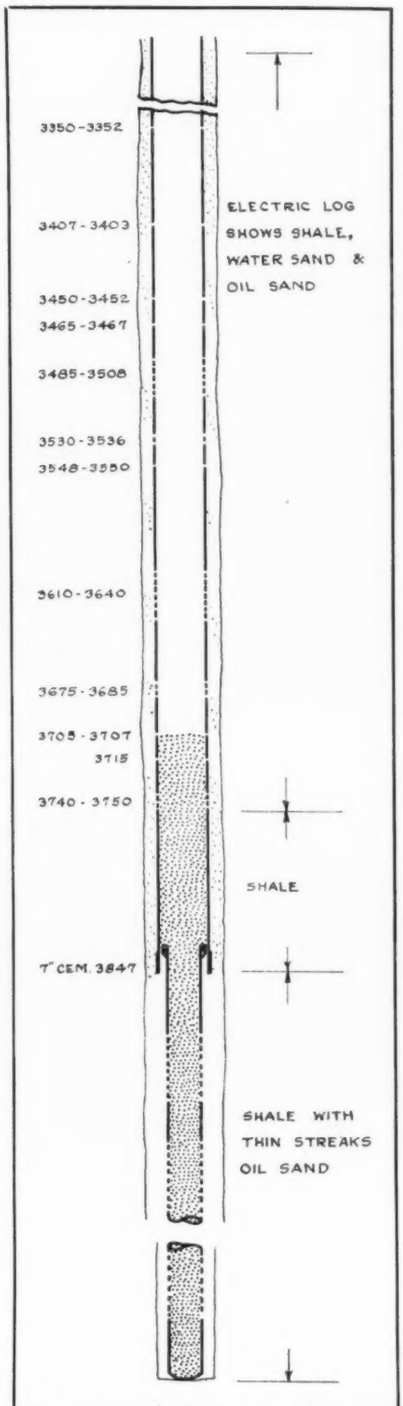

Fig. 5. Water broke into this well while testing and it became necessary to exclude the perforated interval from 3610-40 ft. by cementing

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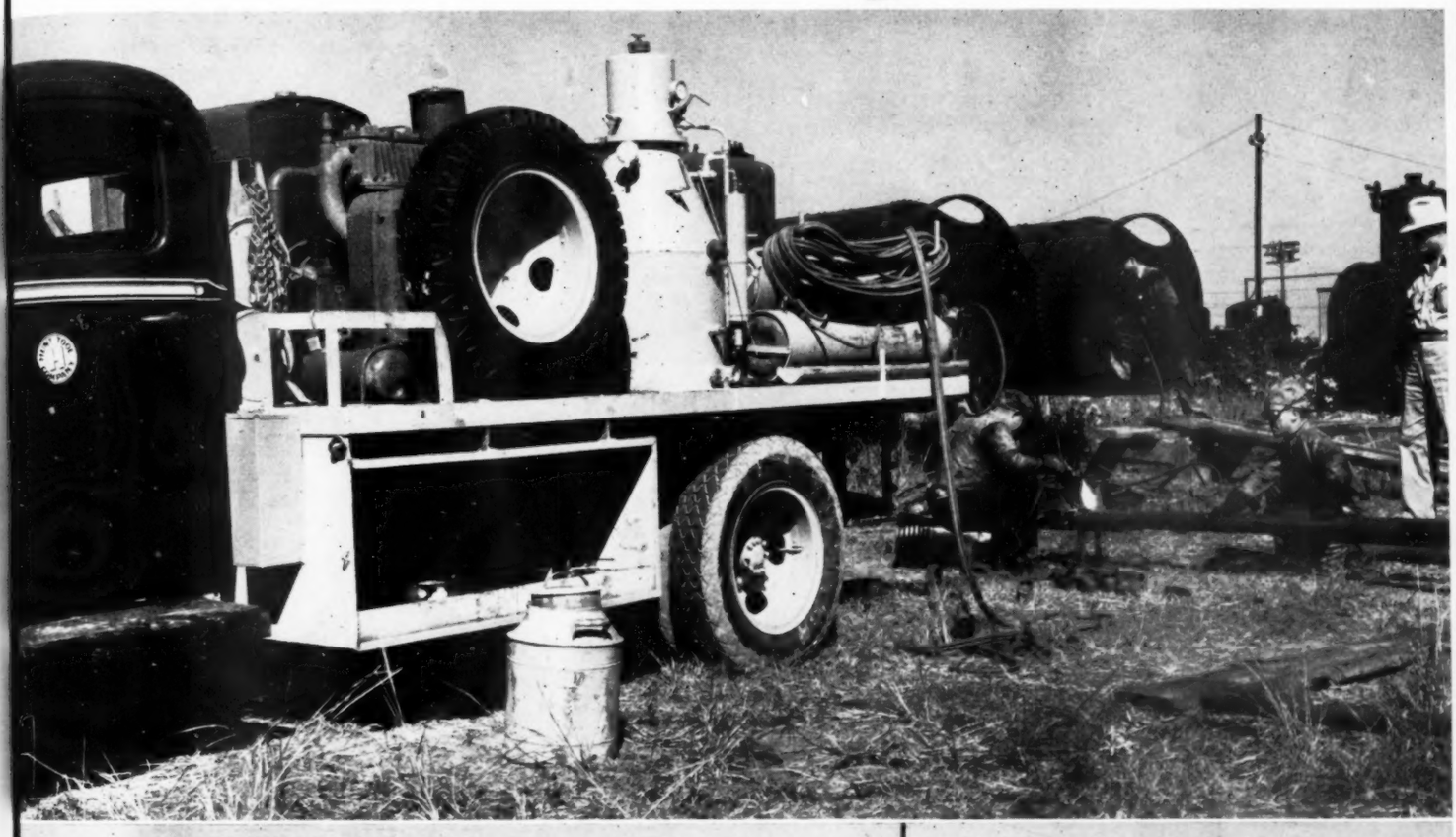

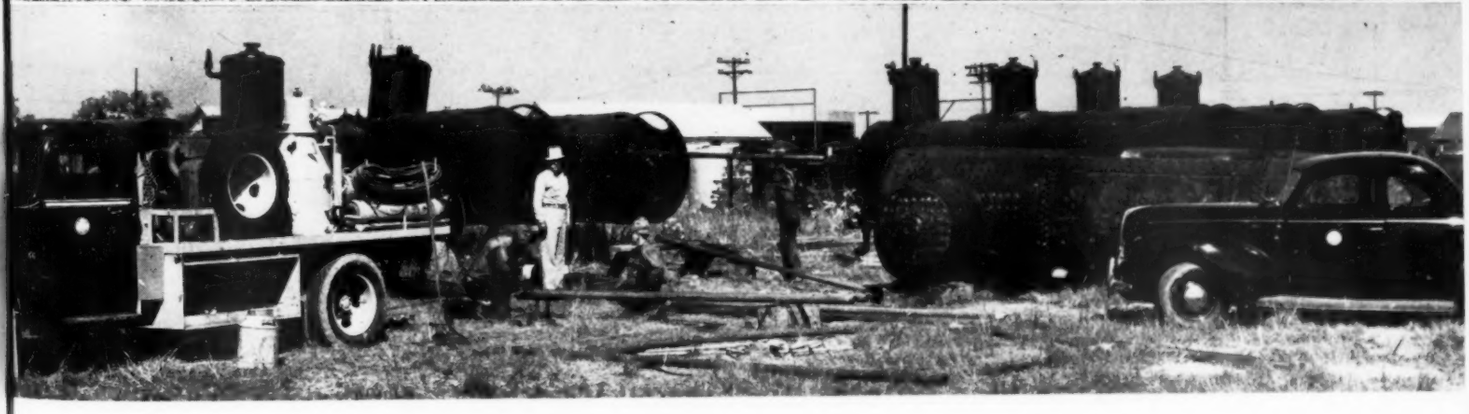

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sure was 1000 lb. and the final pressure was 1800 lb. per sq. in. The head was closed-in prior to placing the cement. The hole was again washed clear of cement and the tool was raised to a safe depth.

After standing 12 hours, the top holes at 3630 ft. were broken open but the holes at 3688 ft. were found to be tight under 2000 lb. Sixty-three sacks of cement were then pumped out through the perforations at 3633 ft. with the pressure increasing from 1000 to 1600 lb. After the cement had set, 1800-lb. pressure was applied and the top holes were found to be tight.

The fluid was bailed to 3000 ft. for a test of shut-off and no water entered the casing in 36 hours. Four ½-in. holes were placed at 3635 ft. and four at 3686 ft. (2 ft. below the top holes and 2 ft. above the bottom holes). A tester with the valve open for one hour, brought out 18 stands of oil, 1 stand of oily mud, 2 stands of gassy oily water, and 1 stand of oil sand (90-ft. stands). The 6⅝-in. casing was gun-perforated with two ½-in. holes per ft. from 3635 ft. to 3686 ft. The well was put on the pump and completed for better than 90 bbl. of 21.9° gravity oil cutting 8 percent.

It should be noted that only the production equipment at the well was used except the c.p. cementer, the casing tester, and the packing-off head. The production crew did all the regular work, thus keeping the entire cost of the project at the minimum.

Fig. 5 shows a well that tested a zone of shale with thin streaks of oil sand. The well produced a small amount of oil. It was considered desirable to test a zone above the 7-ft. shoe, which had shown considerable oil and gas while drilling and which, from the electric log, appeared to be shale with streaks of water sand and oil sand. A few perforations were shot and these lower perforations looked very encouraging on a swabbing test. Additional perforations were placed using a gun-perforator with a final perforation record as shown on Fig. 5. The hole was bridged with sand to about 3708 ft. While testing the sand intervals by means of a packer, water under a high hydraulic head and considerable sand broke in. A water-locating device found the water entering between 3610 and 3626 ft. The problem appeared to be that of excluding the perforated interval from 3610 to 3640 ft. by cementing.

A c.p. cementer with a spread of 40 ft. between opposed packer cups was run on 2½-in. tubing. By means of this tool, circulation was tried on each blank section and it was found that the cement had evidently channeled, for circulation could be established all up and down the perforated interval. The evidence indicated that top water did not have access to the well, however, as the holes at 3350-3352 ft. and 3407-3409 ft. were tight from the beginning.

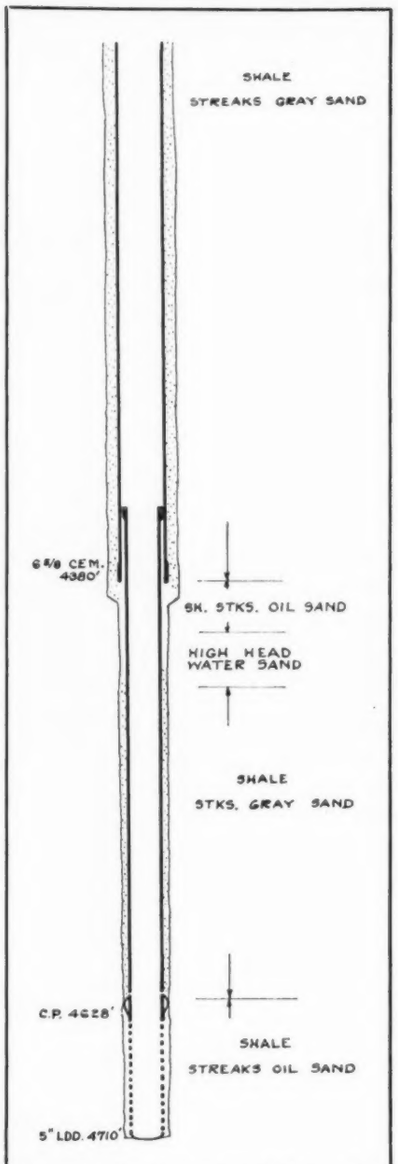

Fig. 6. Showing a special use for the c. p. cementer

The first operations with the c.p. cementer consisting of placing small batches of cement in stages began with the bottom of the tool at 3708 ft. (top of sand bridge). The effect was to cement through the perforations from 3675-3685 ft. and then wash back from the bottom of the tool. The tool was raised and cement was placed 3610-3640 ft., 3530-3550 ft., 3485-3508 ft., and 3450-3467 ft. After allowing the cement to set, the operations were begun at the bottom again and small batches of cement were pumped back of the sections of the 7-in. casing and the excess was washed back each time. When the intervals 3530-3550 ft. and 3485-3508 ft. were reached, a procedure was used similar to that shown in Fig. 4. When the cement started out back of the blank section, the valve on the packing-off head was closed and the cement was pumped away under increased pressure.

After setting for a few hours the tool was again lowered to bottom and it was found that the bridge was more solid and a little higher — probably due to cement going down back of the blank casing and re-entering at the lower perforations. The various intervals again took fluid and were recemented a second time. This time the casinghead was closed-in each time as the cement started out and the cement was displaced under pressure. It was necessary to recement some of the holes a third time to cut out all channels and to get the perforations cemented until they did not break down under pressure.

One important procedure was followed in these cementing operations that was different from those previously described. Instead of back-washing the tool in place after each cementing operation, the tool was lowered sufficiently to cover the previously cemented interval. The time factor and the cost of the cementing equipment did not permit the operator to cement one interval until it was completely shut-off. There were lower perforations still open while cementing the upper stages during most of the operations. It has been previously pointed out that, in this case, the cement could go either upward or downward behind the blank casing. As the operator did not know which way the cement was going, it was necessary to lower the tool to a depth sufficient to cover the perforations below the ones being cemented in order to make sure that the casing was clear of cement.

It should also be noted that the cementing operations reported under Fig. 5 were a combination of the operations reported under Figs. 3 and 4. The differences were those pointed out in the previous paragraph.

A special use of the c.p. cementer is that shown in Fig. 6. A part of the casing record is diagrammed along with the conditions that were to be corrected. A high-head water was entering the well between the 5-in. liner and the 6⅝-in. shoe because there was not a collar of cement to completely fill the annular space between these two casings.

A c.p. cementer was run on 2½-in. tubing with about 10 ft. between the opposed packer cups. The lower cups were the proper size to enter the 5-in. liner and the top cups the proper size to fit the 6⅝-in. casing. A stop on the spacer tube prevented damage to the lower 6⅝-in. cup when the tool was set down on the liner definitely to locate its top. The tool was raised a few feet but

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not far enough to allow the 5-in. cups to pull out of the liner. By manipulating the valve with additional movements of the tubing, the cement was placed and forced out between the opposed packer cups. The cement passed between the 5-in. liner and the 6⅝-in. casing and gradually closed the annular space between them. In the case shown in the diagram, water could be put away under a pressure of 900 lb. and the pressure immediately dropped to 200 lb. when the pump was shut down. Seventy-five sacks of cement were used and 50 sacks were put away under pressures beginning at 900 lb. and increasing to 2000 lb. When the pump was stopped, the pressure remained at 2000 lb. Reverse circulation removed the excess cement from the hole and the lowering of the tool to the stop cleared the hole below the position of the tool while cementing. The one cementing operation corrected the trouble and the well was put on production.

The operation described in Fig. 6 is different from the previously described uses of the c.p. cementer in that the packer cups are of unequal size. The larger cups being above the smaller cups, there is a tendency for the tubing to be raised by the differential hydraulic pressure. In order to offset this differential pressure, sufficient slack should be given to the tubing to prevent the smaller cups from clearing the liner; also, there is a practical pressure limit at which the cementing operations should be concluded. This depends on the relation of the sizes of casing and liner, the weight of the tubing or drill pipe, and the relation of the size of the tubing or drill pipe to the casing. If high breakdown and cementing pressures are anticipated, one service company uses a set of slips above the top packer cups. The increasing pressure sets the slips against the casing and prevents upward movement of the running-in string. As the cementing pressure is released, slips are also released, thus again allowing the movement of the tool and the running-in string. This type of equipment was used on the job described under Fig. 6.

The reader has probably observed that the basic operations of the c.p. cementer are more or less alike. It cannot be emphasized too strongly, however, that the engineer or superintendent should consider the construction of the c.p. cementer, its method of operation, the time of setting of the cement, and particularly the condition of the hole. If, after studying all these factors and it is decided that the c.p. cementer is the correct tool to be used, the work will probably be done quickly and cheaply and with practically no hazard. The plans for the well operations should be elastic enough to allow for slight changes that may become necessary to keep the operations practicable during the work. As this type of tool becomes better known, it is probable that other uses will be developed and slight alterations to the tool may have to be made to fit them.

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P 986.5

Oil Control Board Created For South Dakota

A MEASURE creating an oil and gas conservation board to control exploratory work and possible production in South Dakota was approved by the South Dakota legislature at its 1943 session and signed by the governor.

The board will be composed of the governor, attorney general, secretary of state, state treasurer, commissioner of school and public lands, and the state auditor.

The state geologist and the state engineer will serve in an advisory capacity.

The board will have authority to regulate all oil and gas exploratory work but the measure specifically limits the commission's authority with the provision that it shall have no jurisdiction "to make rules, regulations or orders which restrict or limit production of petroleum, oil or gas in the absence of waste."

The measure establishing the board provides that no wells shall be drilled closer than 200 ft. from any adjacent property line or 500 ft. from another well on the same property. This provision does not apply, however, to core test wells or stratigraphic wells.

The law also provides that the board must be notified of plans for drilling of wells and sets a fee of $25 for each well. If a well-drilling application is denied, a hearing must be granted to the applicant within 20 days after the application was made and the decision must be announced within 25 days. All decisions of the commission can be appealed to circuit courts in the state.

The law also provides that well-drilling applications must carry the exact location of the proposed well, the names and addresses of the owner, operator, contractor, and driller and that the well log, drilling records, drill cutting or cores must be filed with the commission within six months after the well is completed.

The commission must also be given notice of the intention to drill stratigraphic tests and a plugging report must be filed 60 days after the test is completed. No fee is required for stratigraphic tests.

The legislature also passed a measure appropriating $25,000 for the payment of a bonus for the first successful South Dakota oil well but the bill was vetoed by Governor M. Q. Sharpe, who said its constitutionality was questionable.

Also approved by the legislature and signed by the governor were measures requiring more detailed oil and gas leases for filing with county registers of deeds, including the postoffice address of the owner and the legal description of the land and requiring surrender of oil and mineral leases 15 days after they expire.

South Dakota has been the scene of considerable oil exploratory activities during the last three years. About 7,000,000 acres are under lease in South Dakota and its neighboring state of North Dakota and exploratory crews representing several major companies have been active in both states.

Drilling of four wells was begun last summer and work is expected to be resumed on at least some of them this spring.

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Maintenance of Pumping Station Equipment

PETROLEUM ENGINEER Exclusive Feature

PART 2

by E. R. Spencer
Engineering Department,
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REGARDLESS of how large or how small the plant or plants to be maintained, there must be an allocation of responsibility. This is to say that, if machinery is to be properly maintained in operating condition, there must be an organization set up for it. It does not matter how simple or complicated the organization, the owners must have vested in some individual or individuals the responsibility for repairs.

Systematic Maintenance

There have, in the past, been two schools of thought relative to the maintenance of machinery in pipe-line pumping stations. One group advocated the repair of machines if and when they would run no longer. The machines were allowed to run without thought of any systematic inspection or rehabilitation. Such an attitude has been colloquially dubbed the "fix it when it quits" method. This thoughtless procedure has largely given way, however, to more systematic and well-planned programs.

The "short-comings" of a "hit and miss" program of maintenance are apparent. Regardless of how effective and elaborate the other features of a maintenance program might be, it fails unless the actual work is carried out systematically.

The matter of periodic general rehabilitation of pump station equipment is perhaps one of the best examples of systematic procedure. Experience indicates that periodic inspection, adjustment, and repairs are most economical.

With fairly constant conditions, the most economical operating period between overhauls can be determined. The influence of operating condition on the period of overhaul is apparent. The following are a few of the major factors that must be considered when determining the period of operation between overhauls:

(1) Load factor.

(2) Frequency of starting and stopping.

(3) Lubrication.

(4) Fuel.

(5) Climatic conditions.

(6) Protection from dust and other deteriorating agencies.

(7) Practice in making current repairs.

As stated, a study of adequate records and existing conditions will indicate the best period of operation between major overhauls. As an example, it has been found that a period from 8,000 to 10,000 hours of operation between major overhauls of a heavy-duty main-line pumping unit such as used in the Mid-Continent area produces satisfactory results. A similar consideration of all available information will provide a basis for systematizing inspection periods for the major portion of equipment around a pumping plant.

This procedure of setting up definite maintenance schedules should be carried to other more frequent operations. Fuel pumps, for instance, will produce better results if maintained systematically at regular intervals. Space does not permit the listing of each individual maintenance operation that should be placed on a periodic schedule. Such a list should be made for each set of conditions, however, and followed as closely as good judgment will allow.

Standardized Proceedings

A systematic, well-planned maintenance program presupposes standardization. The standardization of maintenance and inspection procedure is one of continual growth. It would be an infinite task to detail the method to be followed on each repair or inspection. On the other hand, however, a standard can be set up on major operations. As an example of the meaning of standard procedures, the outline Table 3, covering the inspection of a heavy-duty main-line pumping unit, is offered. It should be noted that this outline covers inspection only, and is made during the period of general overhaul. It does not attempt to dictate repair procedure.

Insofar as practicable, men making the actual inspection should be provided with an outline covering each particular inspection job. Inspection outlines should be supplemented with specific instructions on repair methods covering the more complicated tasks, such as checking crankshafts and other alignments, liner wear, compressor clearance, valves, etc. Some of these major operations will be discussed in detail later.

If such guides are made up for various types of equipment in the light of existing data and tempered by qualified experience, their value is apparent. The use of an outline similar to Table 3 becomes more valuable when used where large numbers of units are operating under one ownership. It gives the supervisor of maintenance a definite standard to present to those actually making the inspection. Without such a guide, the thoroughness of any inspection will depend on the individual actually doing the work. The wide variation of judgment between mechanics makes the use of similar outlines imperative, if the maintenance program is to be carried on satisfactorily and economically. It will be found that the assurance of complete and thorough inspection of mechanical equipment will more than justify the cost involved.

As already pointed out, standardized procedure should be followed in making repairs and inspections. An outline such as Table 3 would become cumbersome and useless if it carried the details of each operation listed. Supplemental instructions are, therefore, recommended. These instructions can be in either detail or outline form. In either case, they should be brief and cover only the main points of procedure.

Any information relative to the proper maintenance of any particular piece of equipment should be made available to the field men. Standardized adjustment information is especially valuable. The following list will give some indication of the wide range of items that can be tabulated.

1. Back lash in gear teeth.
2. Side clearance of piston rings.
3. Piston ring gap.
4. Piston head clearances.
5. Valve lifts.
6. Valve dimensions.
7. Maximum and minimum temperatures.
8. Compression and firing pressures (max. and min.).
9. Maximum and minimum operating speeds.
10. Bearing clearances.
11. Standard over and under size.

When studying the above partial list

and taking into account the large number of different types of machinery in the average pump station, the vast amount of information involved is apparent.

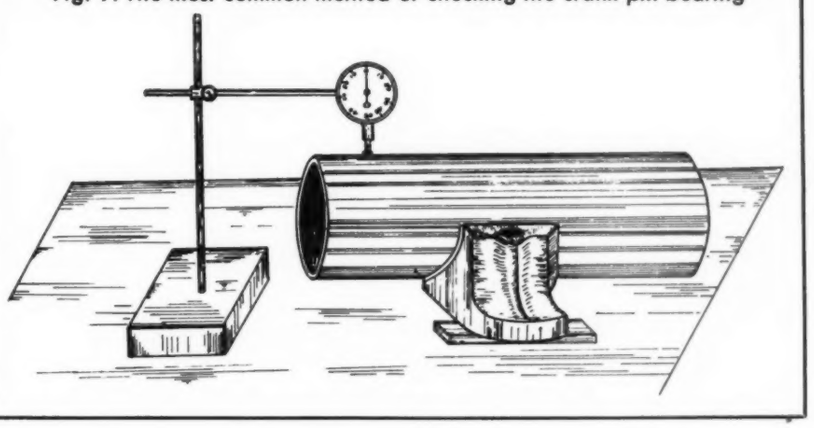
The following is an example of specific standardized instructions and a discussion of several approved methods of checking important alignments.

Specific Standardized Instructions

A routine inspection of the intake and exhaust valves is to be carried out periodically. The kind of fuel and station load factor will influence the frequency of inspection.

Check the rocker arm bore for wear by inserting the fulcrum pin and then measuring the exact amount of wear by means of a thickness gauge. Excessive wear in fulcrum parts shall be corrected by either new parts or remachining the fulcrum pin and rebushing the rocker arm. Inspect the cam rollers for flat surfaces, and check the roller-pins for out-of-round with micrometers. An accurate measurement of wear between roller and pin shall be obtained with a dial indicator attached to the rocker arm with the dial pin resting on the roller. Repair or renew these parts as justified by wear.

Fig. 1. The most common method of checking the crank-pin bearing



Tappet screws and tappet bearing plates or contact surface should then be checked for wear and fracture of case-hardened surfaces. If the parts are worn sufficiently to affect the valve action, the bearing plate should be replaced

TABLE 3

Inspection of main-line Diesel reciprocating pumping unit

I. General

1. Inspection of engine before overhaul, while running or shut down as conditions require.
   - A. Indicate—When possible or advisable, indicate and study compression and firing pressures, noting any other irregularities that may appear on the diagrams.
   - B. Check pressures on water, lube oil, and the three stages of air compressor.
   - C. Inspect all pressure relief valves.
   - D. Check valve timing and lifts.
   - E. Observe governor action.
   - F. Check fuel pump for leaks in plungers, packing, etc.
   - G. Attempt to locate abnormal noises.
   - H. Note any condition not in keeping with good practice.

II. Removal and Inspection of Parts

1. Remove all rocker arms and valve mechanism.
   - A. Examine for flat spots and wear on rollers, pins, bushings, etc.
   - B. Note wear on tappets.
   - C. Check fulcrum pins and bushings for wear.
2. Remove valves from head and recondition.
   - A. Clean and grind until all pits have disappeared. In case valves or seats are warped or badly pitted, it may be necessary to send to machine shop for refacing.
   - B. Inspect valve springs for length and tension.
   - C. Fuel valve should be carefully inspected to determine wear and general condition.
   - D. Inspect all moving parts including valve stems, valve stem bushings, guides, lock washers, etc.
3. Remove main cylinder heads after determining head clearance with lead or copper pipe.
   - A. When convenient, remove exhaust and intake headers; if not convenient, then block in place.
   - B. Clean head. If necessary, use an approved scale remover. As a safety measure, a solution of 2 lb. of baking soda to 10 gal. of water may be used to prevent acid burns.
   - C. Remove all clean-out plates and plugs to facilitate cleaning.
   - D. Examine carefully for defects such as cracks, leakage and bad seats.
   - E. Replace clean-out plugs and plates.
4. Wash engine jackets and exhaust header.
   - A. If scale is present, use approved scale remover.
5. Remove crankcase doors and casings over camshaft drives.
6. Wash out crankcase with kerosine, hot water, or steam.
   - A. Break connections on end of engine to facilitate cleaning. Be sure to replace as soon as cleaning is completed.
7. Block connecting rod bearings.
   - A. Measure bolt length before relieving strain on nut.
   - B. Relieve strain on nut and remeasure bolt length.
   - C. Tighten set screws for holding connecting rod bolts in place and remove nuts.
   - D. Compare measurements made in "A" above with previous measurement when bolts were installed. Compare measurement in "B" with original bolt length.
8. Pull pistons.
   - A. Remove rings and note carefully general conditions and indication of blowby.
   - B. Clean and inspect pistons inside and out for cracks, scores, or other defects.
   - C. Remove piston pins, measure and note dimensions in planes perpendicular and parallel to piston pin. A cradle arrangement may be used in this work to prevent knocking the piston out of round.
   - D. Examine piston pin bearings and adjust to proper clearances. Use a surface plate to determine whether or not the piston pin bearing is true in planes parallel and perpendicular with the crank pin bearing.
   - E. Thoroughly clean oil hole in connecting rod and insert cork until installed.
   - F. Install piston pins in pistons.
   - G. Measure piston skirt.
     1. Use wood block and sledge to adjust piston skirt dimensions to where it is approximately 0.00015 per in. of diameter smaller parallel to the pin than perpendicular to it.
   - H. Where oil-cooled pistons are used, break out oil-cooling header as much as possible and clean.
9. Remove connecting rod bearings from crankcase.
   - A. Inspect carefully for cracks, loose babbitt, or other defects.
   - B. Inspect connecting rod bolts very carefully. Note bearing surface under head and evidence of damage.
   - C. Suspend connecting rod bolts from string (non-metallic) and sound for cracks.
10. Measure with micrometers the distance between crank webs.
    - A. Take measurements on all cranks in the four quarter pistons.
11. Remove main bearing caps. (Outboard bearing is considered as main bearing.)
    - A. Inspect for cracks, loose babbitt, and evidence of heavy bearing areas.
    - B. Inspect journals for light and dark spots.
12. Take bridge gauge readings on all main bearings.
    - A. If bridge gauge is not at hand, spot frame directly above journal and measure distance between spot and shaft.
    - B. Press shaft into shell with either clamp or jack and take second bridge gauge reading.
    - C. In case deflection in item 10 is more than 0.002 in. in any one position, remeasure the distance between crank webb at the point in question while shaft is clamped in bearing.
    - D. Examine crankshaft for cracks. (Paint with alcohol and chalk.)
    - E. Bridge gauge reading of main bearings before and after pressing down should never vary more than 0.002 in.
13. With approved shafting level determine position of all main journals.
    - A. Determine pitch to foot and direction of slope.
14. Roll main bearing shells out of socket, inspect for defects, and evidence of relative pressures.
    - A. Compare thickness if necessary.
15. From numbers 11 to 14 above determine the cause of crankshaft misalignment, if any.
    - A. A crude sketch of crankshaft showing journal levels and web distances will aid materially in finding the cause of misalignment.
    - B. Leave crankshaft with not more than 0.002 in. difference in measurements between crank webs in any two diametrically opposite positions.
16. Replace main bearing caps and lower shells giving proper clearance after all oil passages have been thoroughly cleaned.
    - A. Clean all oil passages and piping with air, steam or any other approved method at hand.
    - B. Take leads on bearings with original shims. From this information determine amount of shims to be removed to insure proper clearance.
    - C. The rule generally followed for main bearing clearance is to allow 0.005 in. clearance per in. of diameter and to this amount add 0.002 in.; this a 10-ft. shaft will require 0.007-in. clearance.
    - D. Use precaution to insure the pulling down of cap evenly and squarely with the main frame.
    - E. Check crankshaft end thrust and as far as possible, adjust to manufacturer's recommendations.
17. Inspect vertical shaft and shaft drive, or other camshaft drives.
    - A. Remove all housing necessary.
    - B. Inspect and adjust bearing clearances and thrust.

(Continued)

with a new one and the tappet screw repaired or renewed.

After removing the valves from the engine, inspect the seating surface in the cylinder head to determine whether leakage of gas is evident. Leakage may be the result of a warped valve, dirty seat, warped or worn seat, or a bad gasket.

The seating surface in the cylinder head shall be checked for warpage. This can be accomplished by "bluing" and turning a new seat on its corresponding seat in the cylinder head. If this surface is warped, it may be ground in, with the cylinder head in place, by using a flat machined plate of the same diameter as the seat; attach a "tee" handle to this plate to simplify grinding. If necessary, the seat may be remachined on the job by a special portable cutting machine.

Any deposits of carbon on the valve stem should be noted, as this may indicate a worn guide bushing. After the valves have been dismantled, the bushing wear can be accurately determined. If repairs are necessary, the bushing should be renewed or the cage bored and a new bushing installed.

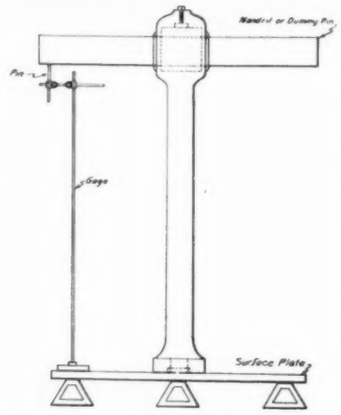


Fig. 2. One method of checking the bore of the piston-pin bearing relative to the big end of the connecting rod

If the valve disk and seat are pitted badly or worn enough to form shoulders, they should be refaced before attempting to grind them.

When valves have been cleaned, the seat and cage should be checked for warped surfaces. A set of thickness gauges may be used to detect warpage or the seat may be "blued" and rotated in position on the cage. In case there is some doubt as to the condition of the removed seat, a new seat or one that has been refaced can be used. If there are indications of warped surfaces, all parts concerned must be refaced or remachined.

Before grinding the valve to its seat in the cage, the valve cage should be placed in a vertical position, with the seat on top, on a table or improvised bench. The valve is then inserted into the cage and with a grinding compound the two seating surfaces are ground together. A medium grade grinding compound should be used until the seats are free of pits and burrs, then use a fine grade of compound to polish the two surfaces. After grinding and polishing,

TABLE 3—Continued

Inspection of main-line Diesel reciprocating pumping unit

C. Note gear clearance and wear.
D. Inspect timing chain and pinion for tension, wear, and other defects.

18. Examine camshaft.
A. Adjust bearing clearance and thrust.
B. See that all cams are tight and in proper position.
C. Examine cams for excessive wear.

19. Check fuel pump and fuel piping.
A. Check all moving parts such as pins, bushings, crossheads, links, straps, eccentrics, etc., for excessive wear defects and adjustments.
B. Check and repair all pump, check, and try valves, removing valve bodies when necessary.
C. Reset governing valves to manufacturer's recommendations.
D. Be sure that all valves have the required spring tension and lift.

20. Inspection of governors.
A. Dismantle the governor and completely overhaul it.
B. Note all joints and bearing races as well as all other moving parts for breakage, wear, and lost motion.
C. See that all nuts, keys, etc., are in place and tight.
D. Make sure that all parts work freely and show no signs of stress.

21. Replace housings on camshaft driving mechanisms.

22. Examine lubricating oil pump.
A. Dismantle lubricating oil pump. Observe general conditions and compare with requirements for satisfactory operation.
B. Note bearing and shaft condition.
C Inspect and renew packing.
D. Note condition and repair driving mechanism.
E. Completely dismantle, clean, and repair relief or bypass valve.

23. Measure line diameter with inside micrometers.
A. Take measurement both parallel and perpendicular to crank pin.
B. Measurements in "A" to be taken near center of liner above oil hole, about 1 in. from top of ring travel, using standard locating iron for determining exact position.
S. If abnormal conditions appear, take other measurements.
D. Operate force-feed lubricator by hand and thoroughly check all lube lines from lubricator to cylinder. Give special attention to the lubricator plugs in cylinder lines.

24. Replace connecting rod bearings.
A. Properly place leads and original shims so that clearance can be determined later.
B. Again carefully inspect connecting rod bolts and replace, securing in position with set screws provided for this purpose.
C. Replace required compression shims.

25. Prepare piston and install.
A. Fit rings in liner and determine end gap, which should be 0.005 in. per in. of diameter of the ring.
B. Determine width and condition of ring grooves in piston.
C. Install rings making sure of proper side clearance.
D. Thoroughly oil lines, piston, and spacer rings; insert assembly.

26. Adjust connecting rod bearing.
A. With piston and connecting rod assembly in place, tighten bearing bolts to insure pinching of lead wire to actual bearing clearance.
B. Remove lead wire to determine original clearance and adjust shim thickness to give required clearance.
C. Tighten bolts in accordance with standardization sheet for the particular engine.
D. Operate hand lubricating oil pump and check to see that oil runs freely through all bearings. Check oil piping for leaks.

27. Replace cylinder heads.
A. See that all contact parts are clean and gaskets annealed.
B. Tighten all head bolts gradually and with equal tension.
C. Check head clearance.

28. Replace valves in head.
A. Make sure that copper gaskets are annealed and cleaned.
B. Clean seats and all contacting surfaces. Make sure that all seats are free from all foreign substances.
C. Tighten valve bolts evenly, moderately tight, allow for expansion. Use a wrench without a cheater for this work.

29. Replace rocker arms.
A. Give all valves recommended roller clearance.

30. Remove all compressor valves.
A. Clean and grind.
B. Check valve lifts where necessary.
C. Carefully examine all parts for excessive lube oil.

31. Measure head clearance on all stages.
A. Use lead for this purpose.

32. Remove head and pull compressor piston.
A. Clean and observe carbon deposit.
B. Inspect rings for wear and defects, replacing those no longer serviceable.
C. Examine and adjust piston pin bearing.
D. Thoroughly examine compressor liners, taking measurements with micrometer whenever advisable.
E. Replace compressor piston.
F. Examine and adjust connecting rod bearing, making proper allowance for head clearance.
G. Inspect all air piping, and air bottles and, when necessary, clean with steam, air, or any other means at hand to insure thorough cleaning. Inspect intercoolers and clean as required, using suitable solutions for boiling out deposits. Sharp tools must not be used for this purpose.

33. Replace compressor head and valves.

34. Set timing on all valves.
A. With a bevel protractor or tram, check opening and closing of inlet and exhaust valves on at least one cylinder.
B. Use air and bevel protractor or tram to set opening and closing of fuel valves.
C. Thoroughly inspect crankcase for rags, blocks, and other loose objects, jointly with station engineer on duty.
D. Replace crankcase doors.

35. Check all foundation and frame bolts.

36. Examine flywheel bolts and see that nuts are tight.

37. Prepare engine for starting in co-operation with the engineer on duty.
A. Operate mechanical lubricator by hand to insure oil supply to pistons.
B. Bar engine over several complete revolutions and spot.
C. Check air pressure in starting and injection bottles.
D. See that wrenches and all other material are out of the way of moving parts on the entire unit.
E. Take other necessary steps common to starting the engine.

38. Start engine.
A. Operating engineer should start unit. The machinists should not touch gate valves, switches or other apparatus incident to plant operation unless the engineer is present.
B. Operator should stay near throttle for first few minutes.
C. Engine should be shut down, doors removed, and inspection made within ten minutes after starting.
D. Inspect 30 minutes after the first stop. Then run for two hours at full load and inspect. Then run for four hours at full load and inspect. If the inspection is satisfactory to the engineer and mechanic, the engine should be placed in the line for a 24-hour run at full load.

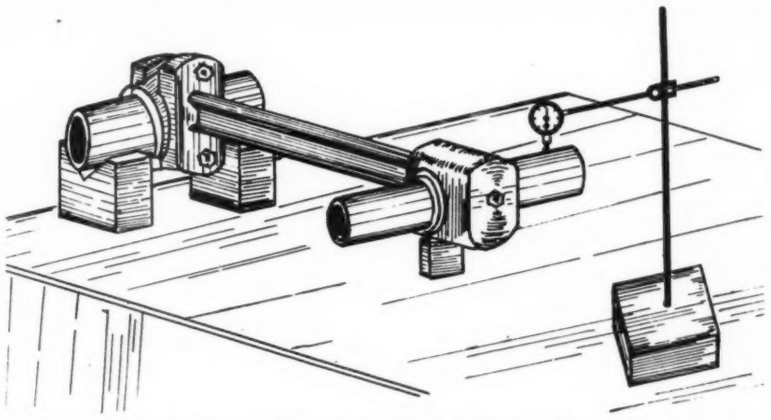


Fig. 3. A method commonly used to check the parallelism of the bearing bores relative to each other

the valve should be "blued" and rotated on the seat to test for a complete surface contact between valve and seat.

The valve mechanism can now be assembled giving special attention to the spring length and tension. It is evident that removal of metal from the valve seat and cage during the grinding and truing-up process materially affects the tension of the spring when it is in place. Washers placed under the spring in an amount equal to the metal removed will keep the spring tension normal.

The valve assembly is now ready to be placed in the engine. The seat in the head should be cleaned and inspected. If gaskets are used, place a new gasket on the valve cage seat. Care should be exercised when placing the valve cage in the cylinder head to see that the gasket does not become damaged. Enough emphasis cannot be placed on the proper installation of the valve cage into the cylinder head. The valve cage stud nuts should be tightened just enough to prevent leakage of gas. Any excessive strain placed on a cage type valve by over, or uneven, tightening of the cage nuts will cause distortion and the valve assembly will not function properly. When cylinder heads have been removed and time permits, the final grinding should be completed after the cage has been installed. This procedure will eliminate any possibility of seat warpage caused by tightening of cage bolts.

After the valves and rocker arms are assembled in the engine, the rocker arm roller-to-cam clearance should be set as recommended by the engine manufacturers.

Checking Alignments and Bearing Clearances

In all machinery it is very important that the crank-pin and piston-pin bearings are true in every respect. The bore of each bearing must be parallel to the crank-pin in order to obtain satisfactory results in operation.

There are several methods of checking the bore and alignment of these bearings. The most common method of checking the crank-pin bearing is shown in Fig. 1. The mandril or "dummy pin" is machined to the exact diameter of the crank-pin and long enough to allow suitable overhang at each end for measuring purposes. The bearing is then placed on a surface plate supported by two identical and accurately machined metal strips in order to clear the "boss" that is present on many bearings of this type. The mandril is then placed in the bearing, and by means of a surface gauge with a dial indicator attached, one can set the dial indicator and move it directly across the top of the mandril and observe the maximum dial reading. This operation, with the same setting of the dial indicator, is repeated on the other end of the mandril and the maximum reading again observed. The two readings should be the same. An ordinary surface pin gauge will serve the purpose of checking the parallelism of the mandril and surface plate. When dial indicators or micrometer calipers are used, however, one can determine the amount of taper in the bearing, should the bore not be true.

It is good practice always to "blue" the mandril and rotate it in the bearing to check the seating surface before the above test is made. There may be "burrs" or dirt and carbon that will need scraping away in order to allow the mandril to rest in the entire seat of the bearing, thereby relieving the possibility of erroneous readings.

It is important that the piston-pin bearing bore, as well as the crank bearing bore, be parallel to the crank-pin. In Fig. 2 is shown one method of checking the bore of the piston-pin bearing relative to the big end of the connecting rod. A mandril is machined the exact diameter as that of the piston-pin. The mandril is "blued" and the seating surface of the bearing checked; then the mandril is clamped in place by the adjusting screw and bearing halves, less the shims, and the rod is placed in a standing position on a surface plate. By means of a gauge, which consists of a rod of sufficient length made to accommodate small micrometer calipers or a pin assembly at one end and a surface block at the other end, the distance can be determined between the surface plate and each end of the mandril or "dummy pin." This will readily show the alignment of the bearing bore with respect to the bottom of the connecting rod. An ordinary pin gauge will suffice for this check when micrometer calipers are not available. The advantage of using micrometers is the quick adjustment and the ascertaining of the exact amount of taper in the event the bore is not true with the bottom of the piston rod.

The bores of the piston pin and crank pin bearings may be in horizontal planes parallel to the crank pin, yet the two bearing bores may not be in the same vertical plane. This condition may occur when a connecting rod is twisted or when either or both the piston pin and crank pin bearings are not bored true. Equipment in this condition is detrimental and should not be tolerated. Fig. 3 shows a method commonly used to check the parallelism of the bearing bores relative to each other. Both mandrils are clamped in the bearings with the bearing halves or caps without shims; the rod is then laid on a surface plate with two "V" blocks supporting the crank pin mandril. The other end of the rod is supported by blocking or wedges near the piston pin bearing. Of course, the two "V" blocks must be accurate in construction and identical in order to get the required results. A check on the "V" blocks can be obtained by measuring from the surface plate to the top of the mandril at each end with the same gauge as used in checking the crank pin bearing in Fig. 1. The distances between the surface plate and the top of each end of the piston pin mandril, if equal, will indicate that the two mandrils are in the same plane.

This assembly in Fig. 3 will also serve the purpose of checking the parallelism of the bearing bores with respect to one another by measuring between the two mandrils at each end. These distances should be equal.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

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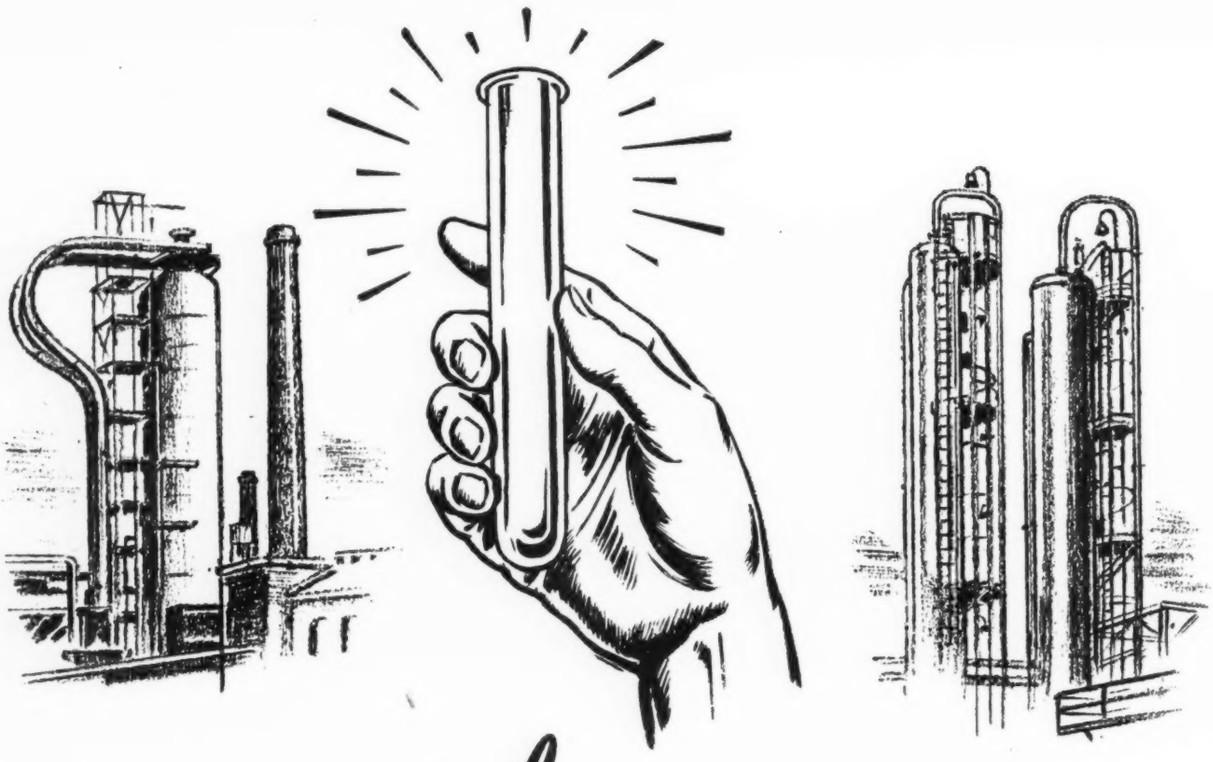

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Vane-Type Rotary Pumps

Characteristics of the swinging, or bucket, type and sliding vane type pumps

by Bruce P. Hetler

Manager, Engineering Sales, Blackmer Pump Company

IN the discussion of any particular type of rotary pump, it is helpful to consider rotary pumps as a class in comparison with other standard types of pumps. The rotary is a positive displacement pump that combines the compactness and continuous flow features of centrifugal pumps with the positive action of reciprocating pumps. Development of many of the modern industrial processes has been made possible because of the characteristics of rotary pumps and their ability to handle liquids not pumpable with other types of pumps.

Generally speaking, rotary pumps may be divided into six groups: vane, external gear, internal gear, screw, cam and piston, and lobe. The flow is continuous in most cases, and all are of the positive displacement type. The difference among the various types is in the mechanical design of the working elements and their relation to the pump casing.

The efficiency of a rotary pump in making high suction lifts without priming, and in developing high pressures, depends upon the clearances between the rotating elements and the pump case. Sustained volumetric efficiency depends upon the maintenance of these clearances—the closer the clearance the higher the volumetric efficiency. In the vane type rotary, the clearances are maintained automatically by the self-adjusting action of the vanes. In other types, the clearances must be kept within practical operating limits by manual adjustment or replacement of worn elements.

Vane pumps are divided into two types: the swinging vane, or bucket type, and the sliding vane type. Fig. 1 illustrates the swinging vane pump, and Fig. 2 illustrates a typical sliding vane construction. Briefly the principle of operation of the two types is as follows: With the rotor turning in a counter-clockwise direction, the vanes or buckets are held against the cylinder wall by centrifugal force. As the rotor turns, the liquid is drawn into the pump at the left and forced out at the top because of the close-fitting portion, which acts as a seal between the intake and discharge openings.

In any comparison of vane pumps with the other types, perhaps the most important point is the fact that the clearances are automatically maintained, because the vanes are self-adjusting for wear. The vanes are usually made of a material that is softer than the pump case, and therefore the vanes take the brunt of the wear. As the points of these vanes wear off, they merely come out of the rotor a little farther to maintain the same contact with the casing wall. When they have worn to the point where they are no longer properly supported by the rotor, the capacity of the pump declines abruptly and the vanes must be replaced. Replacement of vanes is a simple operation, normally requiring less than 20 minutes time. This is one of the reasons why vane type pumps have a low maintenance cost for their units.

Another favorable factor in this principle of operation, is that the liquid is not churned or foamed as it passes through the pump, thus making this type of pump practicable for handling liquids of a volatile nature that cannot be agitated. The recesses in the rotor are filled during its first revolution, and this liquid remains in the rotor recesses while the pump is in operation. As the pumpage passes directly through the pump many liquids containing particles in suspension can be handled without crushing the particles. A typical example of such a material would be whole-kernel corn, which degrades rapidly due to crushing of the kernels.

BRUCE P. HETLER

became affiliated with the Blackmer Pump Company, Grand Rapids, Michigan, in 1922 while still in High School, working in the drafting room full time during vacations and part time the rest of the year—After graduation he continued with the company as a draftsman on a full-time basis, carrying on engineering studies during spare time through extension courses of the University of Michigan and Detroit University—In 1928 he was made assistant chief engineer and became chief engineer in 1930—In 1934 he was made general sales manager, continuing in that capacity until 1940 when he assumed his present position.

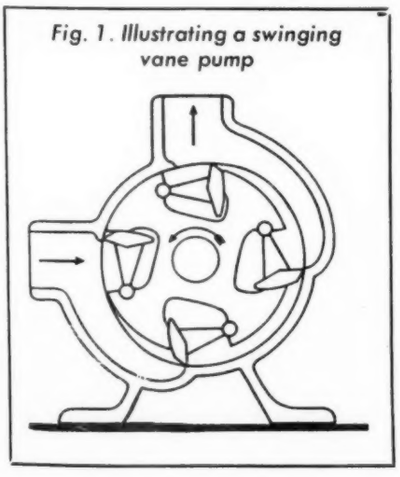

Fig. 1. Illustrating a swinging vane pump

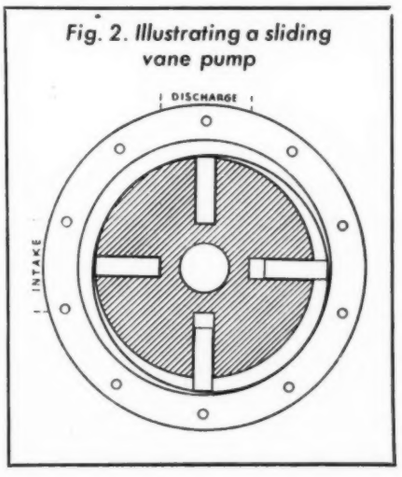

Fig. 2. Illustrating a sliding vane pump

Sliding Vane Pump

The principle of operation of a sliding vane pump is quite simple. The bore of the casing is a true circle, with the rotor offset from the center to a point that permits minimum working clearance between the intake and discharge ports. This is the "sealing point." As the rotor turns, the vanes are held by centrifugal force in contact with the casing well, drawing the liquid in at the intake port and forcing it out the discharge port.

Swinging Vane Type

Although the basic principle of operation of the swinging vane type of pump is almost identical to that of the sliding vane type, it differs in the action of the vane. It can be best described by referring to Figs. 3 to 6, inclusive. In these four diagrams the lighter portion indicates the intake or suction area of the pump, and the darker portion indicates the pressure area. For purposes of illustration, assume a condition in which the pump has been filled with liquid and is just beginning its first revolution. The action of the two buckets or vanes, lettered A and B, should be followed: In Fig. 3, bucket A has moved through the seal segment between the intake and discharge area and is at the edge of the intake port. The casing wall, supporting the edge of the bucket as it passes over the intake port opening, is indicated by the black line. Fig. 4 shows the bucket as having passed over the intake port and is now at the end of the port. As it passes the end of the port, two actions take place. The liquid ahead of the bucket is being pushed forward, and, as the area behind the bucket is increasing in volume, a vacuum is created. This vacuum draws more liquid into the pump. At this point bucket B is beginning to move out of the rotor the same as bucket A in Fig. 3. Now in Fig. 5 we have reached the point where bucket A crosses the edge of the discharge port. Bucket B has just crossed the end of the intake port. At this point bucket B is beginning the same action as described in Fig. 4 for bucket A.

Observing Fig. 6, we find that bucket A has moved back into the rotor and the area ahead of it has reached practically zero.

In describing the action of these pumps only two buckets or vanes have been considered. The same action takes place for each bucket.

In the swinging vane pumps, the sealing area is an arc of a circle having the same center as the rotor. This surface seal reduces the amount of slippage at

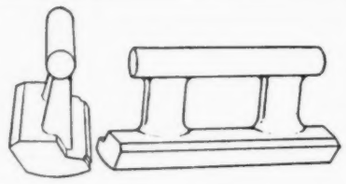

Fig. 7. This and Fig. 8 show a typical swinging vane and rotor recess design

that point to a minimum and has the effect of increasing the maximum suction lift or vacuum that the pump can develop, as well as maintaining a high volumetric efficiency even against high discharge pressures.

The figures showing the principle of operation are more or less diagrammatic, and actually the space between the end of the intake port and the beginning of the discharge port at the bottom of the pump is approximately 10 degrees

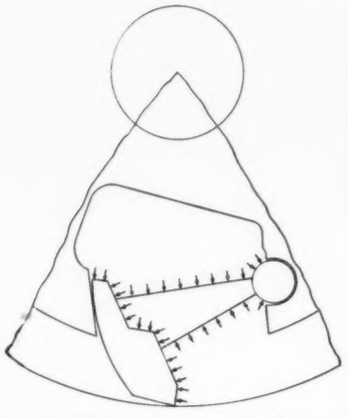

Fig. 8. The manner in which vanes of swinging vane pump are hydraulically balanced

greater than the space between each bucket.

Volume Does Not Change

No change in volume occurs as the buckets pass through the extension chamber between the ports. The casing wall between the sealing arc and the extension chamber arc is a mathematical curve, which is designed properly to control the movement of the vanes as they move in and out of the rotor.

In pumps having a circular bore casing, as the sliding vane type, the vanes are moving either out of the rotor or back into the rotor recess during the entire rotating cycle. In the swinging vane pumps, when the buckets are passing over the seal segment and the extension chamber, no movement in and out of the rotor takes place, as these surfaces are concentric with the rotor surface. The only time the vanes or buckets are moving is when they pass over the two port openings. Actually they are doing no work at these times and are therefore not under load. This accounts for the very high mechanical efficiency that can be obtained with this construction, because the buckets are not required to move in and out of the rotor when they are under load.

Figs. 7 and 8 show a typical swinging vane or bucket and rotor recess design. The hinged part of the bucket is connected to the bottom portion by legs. This allows liquid to get back of the bucket into the rotor recess. Fig. 8 shows how the vanes are hydraulically balanced. The arrows show the liquid pressure exerted on almost the entire bucket surface. With this balancing, the pressure of the bucket against the casing wall is only increased slightly with an increase in operating pressure. The clearance between the rotor recess and the bucket is such that it permits movement of the bucket to get full effect of the hydraulic balancing.

With both the swinging vane and sliding vane types of rotary pumps, it is possible to handle a very wide range of liquids with no material change in the pump constructions. This is important in plants where it is necessary to handle many different kinds of liquids having a wide range of viscosity.

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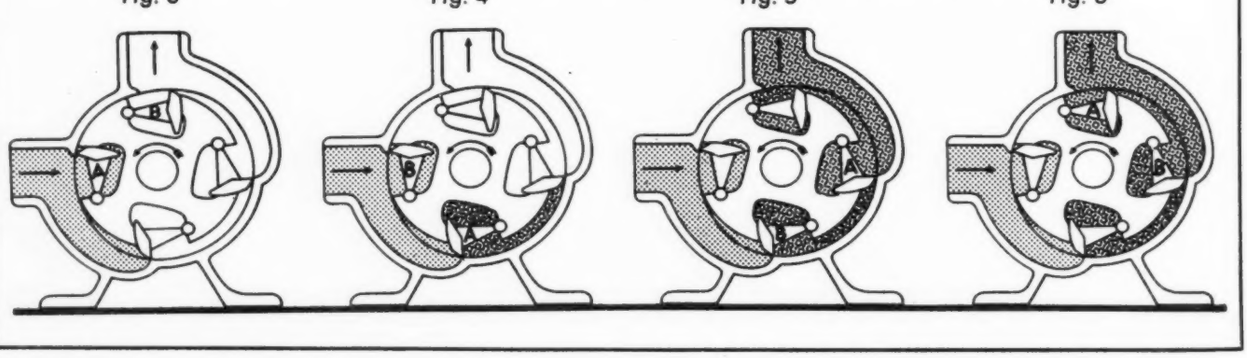
Illustrating the basic principle of operation of the swinging vane type pump



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Inspection and Analysis Of Formation Samples

☆ **Selection and preparation of formation samples for laboratory inspection**

by Lester C. Uren

Professor of Petroleum Engineering, University of California

WITHIN recent years much has been contributed to the improvement of methods of sampling oil- and gas-producing formations; conducting laboratory inspections of formation samples; interpreting the results of such inspections and applying them in the solution of modern petroleum engineering problems. Only within the last two decades have formation samples been regarded as of sufficient importance and interest to justify quantitative inspection and analysis. During the first of these decades methods were primitive and their application of somewhat uncertain value. The last decade has witnessed full acceptance by the petroleum production technologist of approved inspection and test methods as applied to formation samples, and an appreciation of their importance and significance. Very recent research in this phase of petroleum engineering has been directed toward refinement and standardization of analytical methods and improved accuracy and dependability of results.

Any review of the test methods used in the inspection of formation samples would be incomplete without consideration of the methods of procuring such samples, their character, the procedure in handling them at the wellhead and preparing them for shipment to the laboratory. The present article will be concerned with this preliminary phase. Later discussion will review the test methods employed in the laboratory and explain methods of interpreting and applying the results.

Types of formation samples and their comparative value for quantitative inspection purposes. We may classify formation samples primarily, in accordance with the system of drilling employed in procuring them. Thus, in cable or churn drilling, we may seek: (1) bailer samples, (2) bit samples, (3) chip samples, or (4) cable-tool cores. In drilling by rotary methods, we may procure formation samples (5) by washing fragments from drilling fluid circulated to the surface, (6) by coring with conventional types of rotary core barrels operated on drill pipe, (7) by "wire line" retrievable core barrels, (8) by the hydraulically-actuated side-wall coring tool, (9) by coring with diamond-drilling equipment, or (10) by the pressure-type core barrel. Other types of formation samples that may be procured in the drilling of wells either by churn or rotary methods, include (11) side-wall samples obtained with retrievable punch-type coring cylinders propelled by explosives, and (12) formation fragments drawn into the barrels of guns in gun-perforators by resurgence of the well fluid after discharge of the bullets.

LESTER C. UREN

Conditions attending the routine of drilling and economic considerations will determine which of these methods of procuring formation samples will be employed. Each has its own inherent advantages and disadvantages. Cable drilling often produces coarse fragments of the formation in which the drill has been working, retrieved from bottom either by bailers of conventional type or suction type (such as the Cavins Bailer). Frequently, on withdrawing the drilling tools to the surface, bit samples as large as one's fist will be found embedded in clay adhering to the water courses of the bit. Cable-tool bailer and bit samples are of somewhat uncertain value inasmuch as they may be contaminated by cavings from the wall of the well some distance above bottom and only the harder portions of the formation persist in the form of fragments large enough to be of use for analytical purposes. "Chip" samples are obtained by employing a bit dressed to a sharp edge so that it cuts coarse flakes from the formation, instead of the ordinary cable-tool bit, which develops more of a crushing action. Cable-tool core barrels, such as the Baker barrel, are designed to apply the impact action of the cable method of drilling to cut a core from the for-

Later installments of this article, dealing with methods of conducting saturation, porosity, permeability, and other tests commonly applied to formation samples, and of interpreting the results of such tests, will appear in successive issues of *The Petroleum Engineer*. A comprehensive bibliography will be a part of the final installment.

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mation exposed in the bottom of the well. Such a core is likely to be broken into thin "biscuits," seldom more than a few inches long, and the less well consolidated portions of the formation are often disintegrated in the process of coring. Yet, in hard formations, where the cable tools are most used, fairly dependable and little disturbed formation samples may be procured by this means.

With rotary equipment, the "returns" circulated to the surface with the drilling fluid are usually too far disintegrated to be of service for other than qualitative inspection, and recourse is usually had to the use of a double-barrel type of coring tool when formation samples are desired for quantitative tests. Proper choice of a suitable type of cutting head for the core barrel to adapt it to the formation in which the core is to be taken, will make it possible to procure fairly satisfactory and dependable samples under a wide variety of conditions. In soft, unconsolidated formations, pressure applied by the cutting element may result in partial disintegration of the less well indurated portions of the core so that the percentage recovery of the cored interval is not so large as might be desired. Also, the core is caked with clay from the drilling fluid, but this can be scraped off and the core may be several inches in diameter so that the interior, near the center, is uncontaminated by drilling fluid. Wire-line retrievable core barrels are used primarily because they permit of taking cores of the formation in the path of the drill without interrupting progress by withdrawing the drill pipe from the well. Though obtained at lower cost, they are of smaller diameter and therefore less well adapted for quantitative inspection.

At times it is desirable to procure a core sample from the wall of a well in formation previously penetrated by the drill. For this purpose, the Baker sidewall coring tool, actuated by pressure of the drilling fluid, is available. The core is punched out of the formation by a sharp-edged cylinder, and is a thoroughly dependable sample, though of somewhat small size for analytical inspection. Of the several types of formation samples procured by rotary methods, none is more dependable for laboratory study than the diamond-drill core. This may be several inches in diameter and is cut by a diamond-set annular bit that operates with a minimum of pressure, contamination, and compaction of the material cored. The diamond drill procures an unusually high percentage recovery in all types of rocks. No other type of core barrel functions so well in hard formations. The pressure core barrel is designed to cut a core from the formation exposed in the bottom of the well and imprison it in a steel cylinder that can be brought to the surface and transported to the laboratory without reduction of pressure or loss of fluids from the pore spaces of the rock cored.

Gun-perforating operations often bring to the surface in the gun chambers small fragments of the formation opposite the perforations formed in the casing. The samples are too small, however, to be of service in quantitative studies. Side-wall cores are procured by the Schlumberger sample taker, a device that propels sharp-edged coring cylinders into the wall of the well with the aid of explosives. The steel cylinders, attached by steel springs to the "gun" body, are retrieved with their contained cores on withdrawal of the tool from the well. Though ¾ in. in diameter and from 1½ in. to 2½ in. long, cores taken with this device are not so large as are desired for some purposes.

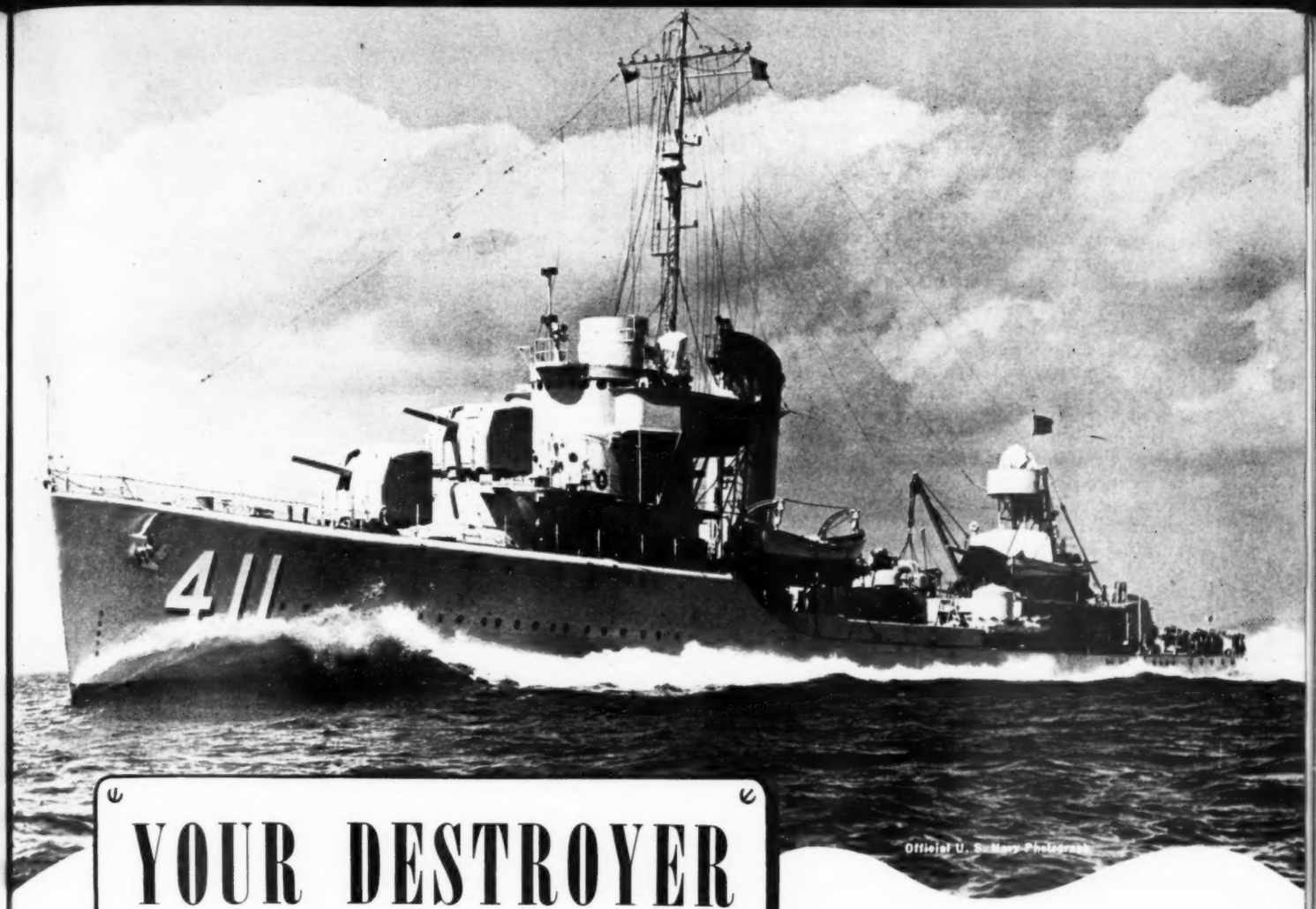
Alteration of formation samples in the process of coring. Excessive bit pressure, sometimes employed in coring, may have a destructive effect upon the material cored, perhaps crushing or shearing the cementing material holding the grains together and compacting the rock structure so that its porosity and permeability are reduced below their actual values in place in the formation. Excessive bit pressure or inadequate supply of drilling fluid may result in sufficient heat being generated to fuse certain minerals in the core, thus seriously altering the lithological properties. Contamination of the core with clay caked about it and driven into its outer pore spaces by the high hydrostatic pressure existing in the bottom of the well often seriously alters the fluid content of cores taken by rotary drilling methods. Granular rocks exercise a selective capillary effect on the well fluid. The superior surface tension of water causes it partially to displace oil from the outer portion of the core. Compaction, resulting from pressure of the cutting tool in coring soft rocks, may squeeze out some of the native rock fluids.

"Bleeding" of the core as it is withdrawn to the surface occasions loss of part of its contained oil and gas. This results from release of gas from solution in the oil and subsequent expansion as pressure is reduced. The jetting effect of drilling fluid against the bottom of the well may result in washing some of the oil from the pores in the path of the cutting tool, so that the core contains less oil and more water than does the formation in place. By cutting large diameter cores and using only the center portions of them for analytical purposes, we can perhaps avoid some of these difficulties, but at best, the worthiness and representative character of the fluid content of a core sample must be viewed with some uncertainty. The oil found in the core on analysis, however, may be regarded as a minimum value, the amount actually present in the formation having been something in excess of this.

Care of the core on reaching the surface. When the core barrel is withdrawn to the surface, the core should be removed from it as soon as possible and carefully inspected by a technologist capable of interpreting his observations in terms of fluid content and lithologic properties. As removed from the core barrel, the core will normally be found broken into segments, some of which may be as much as a foot or more in length, but often only a few inches. After the clay sheath surrounding the core is removed by scraping and washing, the core segments are carefully arranged in a suitable half-round metal or wooden tray, being certain to place all parts of the core in their proper relationships. The depth to top and bottom of the interval cored in the wall is indicated at each end of the core tray by suitable markers, and spacing blocks of suitable length are inserted at intervals between segments of the core when it appears that portions have been lost or destroyed in the process of coring. Core recoveries may at times be but a small percentage of the interval cored as measured by advance of the drill. When two lost intervals occur in the same core, it may be difficult to determine the length of each missing section and the exact depths represented by different portions of the core between the known top and bottom of the interval cored.

Observations are made of the apparent fluid content of different component strata of the core. If gas is present, it may usually be detected by effervescence of small bubbles on the surface of the core. Water or oil, if present with the gas, will be partially expelled on the core surface by gas expansion and the core will appear to "bleed." It is easily possible to distinguish between oil and water thus appearing on the surface of the core. If only small amounts of oil are present, it may be necessary to make tests for its presence upon selected fragments of the core with a suitable solvent, such as chloroform, ether, or carbon tetrachloride. Very light, transparent and almost colorless oils that fail to produce the characteristic discoloration of the ordinary oil solvents may be identified by the acetone test.

A record is preserved of all observations made on first inspection of the core and careful measurements to the top and bottom of each stratum are made with respect to the top of the cored interval, so that an accurate log can be assembled. The position and character of each "parting" or "break" are noted, as well as any peculiarities that may be observed, such as cross-bedding, fault planes, joint planes, solution cavi-



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ties, etc. When the inclination of the strata with respect to the core axis can be clearly observed, the degree of dip should be measured and recorded. The type of rock comprising each stratum can usually be determined by casual inspection. Sands, sandstones, shales, conglomerates, clays, slates, and limestones —the common sedimentary rock types —are sufficiently dissimilar to be identified even by the novice. Appearance of the core materials can be best described as to color while wet. With the aid of a pocket lens the texture is noted; that is, whether the mineral grains are coarse, fine, or medium in size, angular, subangular, or well rounded. Such inspection may also disclose the nature of the cementing material. The more abundant mineral constituents may also be noted, as well as any fossils that may be observed.

Preparations are next made for selecting one or more samples representative of each component stratum. In so doing, care should be taken that the samples selected are, as nearly as possible, truly representative of the full thickness of the stratum from which they come. Samples of the core selected for laboratory inspection may be disks about 1 in. thick, and broken as nearly as possible at right angles to the core axis. Cores of most sedimentary rocks will break readily along the bedding planes under light blows from a small hammer, but if the material is thoroughly cemented it may be necessary to resort to the use of a heavier hammer and chisel to break out the desired portions.

During transportation to a distant laboratory the samples must be protected against loss of contained fluids by evaporation, seepage, or "bleeding." With this purpose in mind they may be dipped in molten paraffin or wrapped in waxed paper, tin, or lead foil. Glass jars with metal screw tops, or ointment tins, may be conveniently used as containers for samples. The latter may be sealed around the lid joint with a strip of friction tape, or they may be dipped in molten paraffin. The container should be marked or a label attached in some permanent way to indicate the well number and the depth from which the sample comes.

It is, of course, an advantage if the laboratory can be near the well, for there is then less time involved in shipment and less opportunity for loss of fluid content of the core. Trailer laboratories, fully equipped for all ordinary core inspection tests, may be stationed at the well where much coring and testing is to be done, thus avoiding the trouble and expense of preparing cores and time lost in shipment. Some of the larger oil companies maintain field laboratories at camp headquarters, within easy trucking of their drilling wells, but many operators utilize the services of testing laboratories situated perhaps many hundreds of miles from the field.

The whole purpose of core analysis is defeated unless the samples selected are truly representative of the formations from which they come. Some authorities question the value of accurate quantitative methods in the laboratory when the difficulties inherent in the problem of procuring representative samples are considered. The core that is brought to the surface is perhaps 4 in. in diameter, or about one-twelfth of a sq. ft. in cross-section. In any study of reservoir conditions this must be considered representative of the strata throughout the surrounding drainage area influenced by the well. If this area is, say, 10 acres, the core is but 0.0000002 of the area that it is supposed to represent. When one considers the variation in lithologic properties that may occur in a sedimentary formation within short distances, the possibility that the well has intersected the strata at a point where average conditions obtain would appear to be remote indeed. It must be admitted that sedimentary formations ordinarily display great variation in texture, porosity, and permeability and that abrupt changes in these properties occur within short distances, both vertically and laterally. In thin-bedded sediments, with rapid alternations of sandy and shaly strata, it may be extremely difficult to procure samples that have representative significance. The natural tendency to select samples that present optimum values in which we may be primarily interested must be resisted. Obviously, a few "grab" samples taken at random are meaningless. The problem is complicated by the fact that the critical factors in which we are primarily interested are masked by mud accumulation and alteration of the exterior surface of the core in the process of cutting. Only one highly experienced in this type of work can be qualified to select representative samples of the core if but a few are to be sent to the laboratory. In view of the uncertainty inherent in the selection process, it would appear that a better plan would be to test a larger number of samples and select them systematically. This does not mean that they should be taken at uniform intervals, for this method obviously would result in the inclusion of many meaningless samples. A sample from the center and from points near the top and bottom of each stratum would yield significant results in most cases, but any plan must be tempered by the good judgment of the engineer or geologist charged with the responsibility of selecting the samples.

Preparation of samples for laboratory inspection. On arrival in the laboratory, the sample is first carefully inspected by the analyst to determine its character and condition. If tests of fluid content are to be made it is important to examine the container and any wrapping that may have been used to determine the extent to which fluids have escaped from the sample during transit from the field to the laboratory. This may be difficult to estimate by casual inspection. Perhaps the best method of determining fluid loss is to weigh the sample in the field on a balance of suitable sensitivity, and then weigh the sample again in the laboratory after it has been removed from its container and wrappings.

After arrival of formation samples in the laboratory they are prepared for subsequent tests to determine fluid content, porosity, permeability, and other lithologic properties that may be of interest. A portion of the sample to be subjected to test is selected and carefully cut or dressed to suitable form and proportions, which will be determined primarily by the requirements of the apparatus employed in determining permeability. Another portion is selected for determination of fluid content.

Apparatus for determining permeability is often designed for use with cylindrical specimens, and in preparing these specimens a small drill press equipped with a diamond-set annular bit is used to cut a cylindrical core about 1 in. in diameter from the sample submitted. The cylinder may be cut from the sample in a direction at right angles to the bedding planes or along the bedding planes, as the objective of the test may require. Often two cylinders will be cut, so that permeability in each direction may be determined. The exact dimensions of the test specimens are determined by careful measurement. A test cylinder cut with the axis at right angles to the bedding planes may be tested for permeability and then a smaller cylinder may be cut from it for further testing, having the axis parallel with the bedding planes. Ends of the cylindrical specimens are carefully dressed with a small diamond-set disk saw, so that they present circular planes at right angles to the cylindrical axis. Careful brushing of the exposed surfaces with a stiff brush will remove from rock pores rock dust formed in the process of cutting and dressing.

Prepared test specimens are next subjected to extraction with a suitable solvent, such as carbon tetrachloride, in a Soxholet extraction apparatus. This removes all oil and water and solid hydrocarbon residues that may be present in the pore spaces of the prepared specimens, which, if allowed to remain, would influence the results of the permeability and porosity tests.

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100-Octane Aviation Gasoline Processes Show Rapid Advance

PART 2

by C. C. Pryor
Associate Editor

DETONATION, the less familiar designation of the term commonly known as "knocking" in an internal-combustion engine, has long been a problem both in designing of engines and in preparation of their fuels. Although no satisfactory explanation of detonation has been found by scientists, it is known that it increases in severity and extent; for example, by an increase of engine compression pressure, local hot spots, and other factors involved in design. The primary factor affecting detonation, however, is the chemical character of the fuel burned.

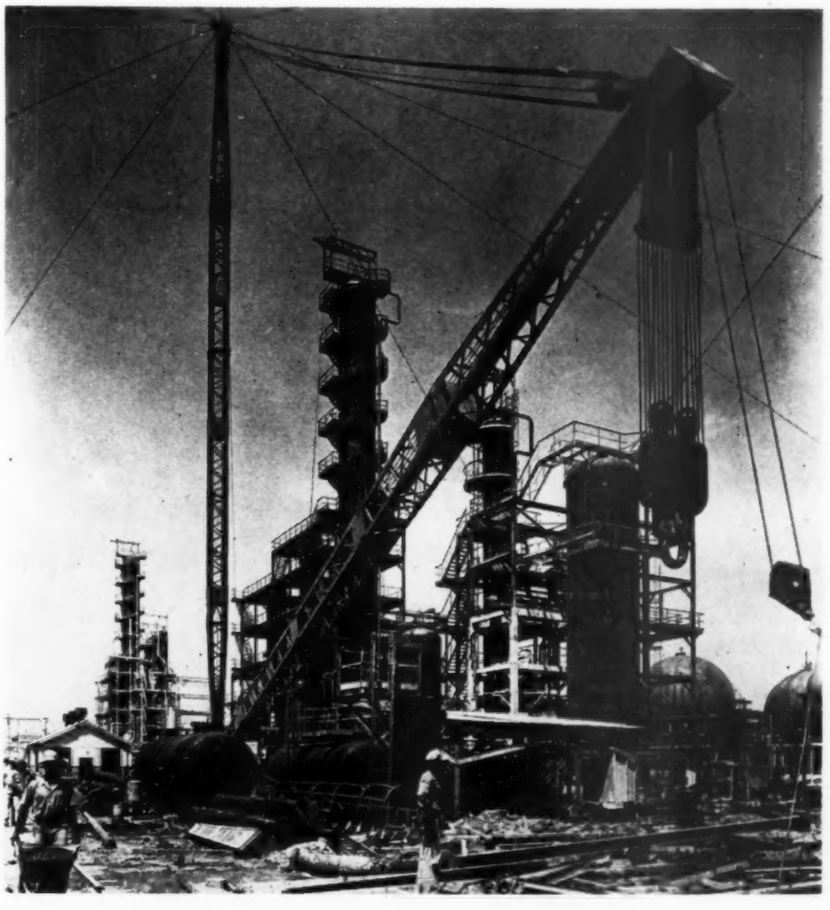
Tetraethyl Lead

Although it is virtually an engineering axiom, that the higher the compression ratios of an internal-combustion engine, the greater the efficiency, for many years definite mechanical limitations prevented increase of compression ratios beyond certain fixed points. In the years immediately after the first World War, however, these mechanical problems were overcome. But knocking persisted, despite solution of these problems.

Two General Motors scientists, Midgely and Boyd, after considerable study found that engine knock was primarily a fuel rather than a mechanical problem. As a result of their studies, a number of highly useful anti-knock agents were found that could be added to fuels to reduce their detonation tendency. Of particular use among these agents was one rather rare compound known as tetraethyl lead.

Obviously, the knock-inhibiting properties of tetraethyl lead have proved a boon to the development of aviation gasoline as well as high grade motor fuels for automobiles. When tetraethyl lead is added to gasoline in quantities as small as three one-hundredths of one percent, the octane rating is raised 10 numbers. In addition, it does not affect the physical or chemical characteristics of gasoline except under the extreme conditions of very high temperature combustion. The one limitation of tetraethyl lead is that its effectiveness decreases as the amount added to gasoline increases. As a result, there is a point beyond which no matter how much tetraethyl lead is added, there is no increase in octane number. The lead content of gasoline is seldom greater than 3 cc., or about 30 drops per gal.

A new alkylation plant under construction for Standard Oil Company of New Jersey for manufacture of blending stocks to increase octane rating of base gasoline



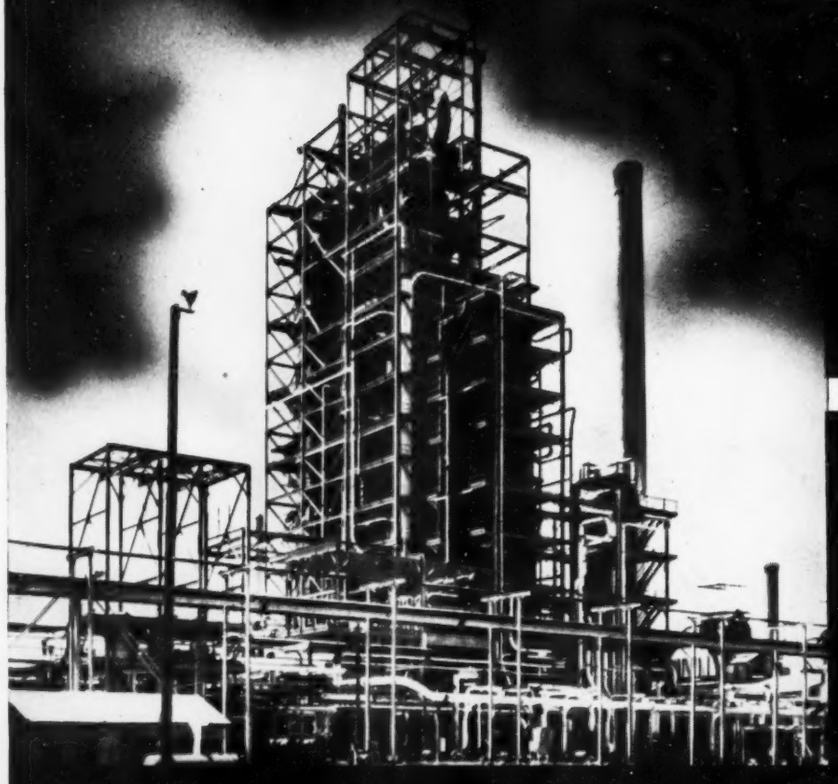
Early Modern Processes

When the army placed its first order for 100 octane-gasoline, the key to the problem was regarded as *iso*octane, which knocks less in the internal-combustion engine than any known fuel. Although *iso*octane is found in crude oil it is in such small quantities that its recovery is not justified.

The first step toward commercial production of *iso*octane was made when waste refinery gases were utilized to produce *iso*butylene. The molecules of *iso*butylene were rearranged to produce di-*iso*butylene. The process obtained from the Germans in 1929 by The Standard Oil Company of New Jersey, hydrogenation, was employed to add the necessary hydrogen atoms to di-*iso*-butylene to convert it to *iso*octane. Until 1938, the hydrogenation process was the most widely used means of manufacturing 100-octane aviation gasoline. Refinery waste gas was used to

(*Continued on Page 82*)

Here's Fast Electrical Help for the AVIATION-GAS PROGRAM



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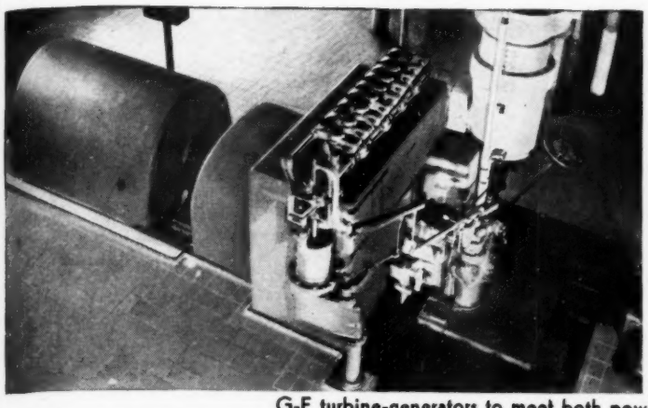
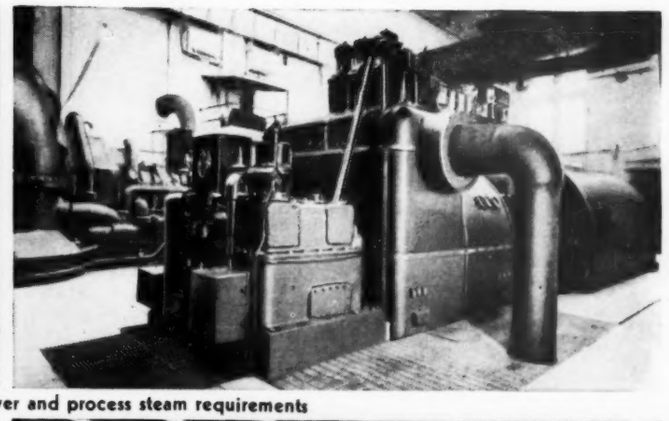
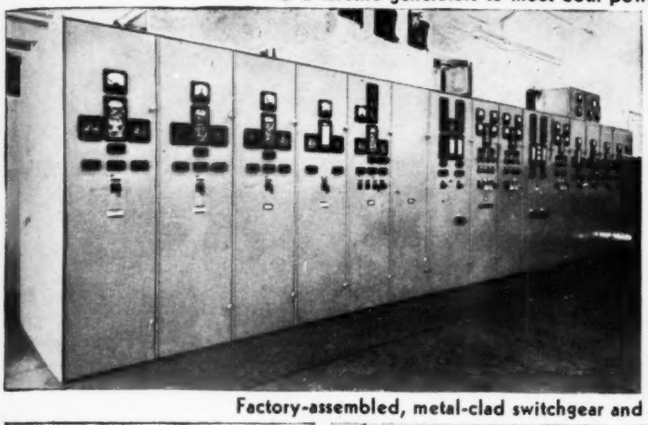
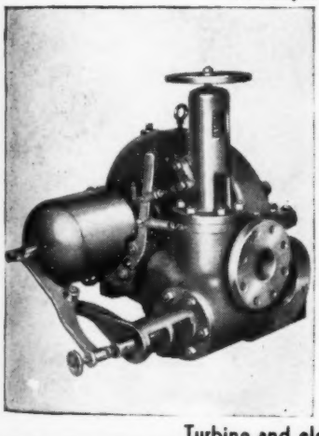




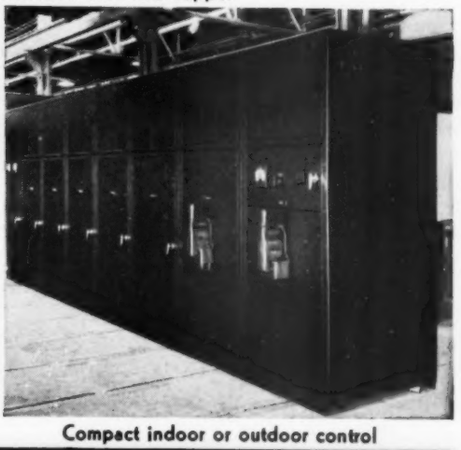
G-E turbine-generators to meet both power and process steam requirements



Factory-assembled, metal-clad switchgear and unit substations save installation time and copper



Turbine and electric drives to fit plant requirements



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GENERAL ELECTRIC

Central control room of a fluid catalytic cracking plant of Standard Oil Company of New Jersey

(*Continued from Page 79*)

heat stills in ordinary refining operations and it was soon found that the quantity of *iso*octane that could be produced was limited by the available refinery gas; furthermore there was not enough *iso*octane in the gases for such quantity production as was necessary. This fact necessitated finding a more expedient method of raising the octane number of gasoline.

As a result of the search in the refiners' laboratories, the alkylation process was developed by means of which blending agents known as alkylates, with an average octane number nearly as high as *iso*octane, could be made without going through the hydrogenation process. Alkylation not only eliminated the hydrogenation process, but utilized numerous other raw materials of petroleum and greatly increased the potential yield of *iso*octane. Among the companies first issued patents for the alkylation process were the Anglo-Iranian Oil Company and the Royal Dutch Shell in England. The Standard Oil Company of New Jersey, The Texas Company, and Universal Oil Products Company were among the first in the United States to receive patents on this type of process.

Operator opening valve to let a batch of selected crude oil flow through to the refinery for manufacture of 100-octane gasoline

Process Pooling

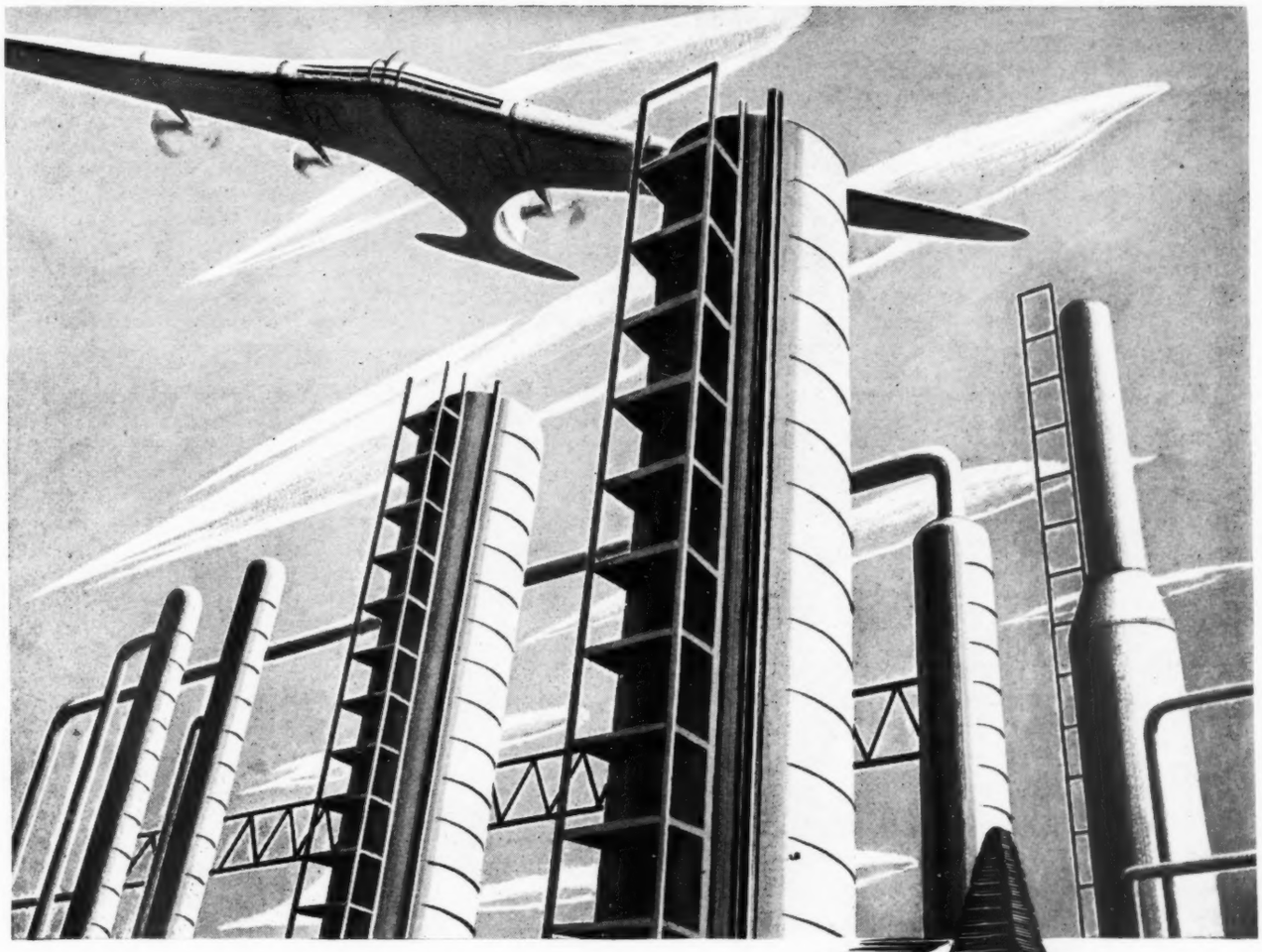
It soon became obvious that several companies were proceeding along parallel lines in alkylation research and that overlapping patent rights would ultimately result in litigation. To prevent such an occurrence, an agreement was formed in April, 1939, among the companies involved for an exchange of patent rights and information to permit a greater and faster development of such an important process. The licenses and other information were widely offered to the industry and complete information turned over to the Government.

As a result of the new agreement, *iso*propyl ether, hydrocodimer, alkylate, and neo-hexane were created. These new discoveries were all capable of forming aviation fuels of 100 octane or higher. New equipment for refineries had to be developed, but by 1940 the petroleum industry was producing more aviation fuel than the military and civilian aircraft of the country needed.

In December, 1940, the late W. S. Farish, president of Standard Oil Company of New Jersey and then chairman of the American Petroleum Institute committee on defense policies, wrote to all the nation's 100-octane aviation gasoline manufacturers, stating that though the then existing capacity to make 100-octane gasoline exceeded demand, the construction of additional facilities was urgently needed in anticipation of the expanding requirements of the ever-spreading war. Farish further recommended storage of as much as possible of the fuel by the Army and Navy in order to keep existing equipment operating at maximum capacity. In addition, he pointed out that at an expenditure of about $30,000,000 the then current output could be doubled within a year.

Rapid Increase of Production

American refineries, as of March 1, 1941, had equipment to produce 16,000 bbl. of alyklate and 4000 bbl. of hydrocodimer per day resulting in conversion



Looking ahead from a long way back

From the early days of "Colonel" Drake and "Coal Oil Johnny," the chemistry of oil has been destined for great things. Greater even than the high-octane gasoline which today is propelling planes across the sky at 400 miles per hour. Greater than butadiene and toluene.

So, too, with the chemistry of alcohols, phenols, esters, ketones and other organic compounds.

The greater things are sure to come. Many are already germinating—secretly in some instances—and heading toward enriching the world of tomorrow.

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to about 40,000 bbl. per day of 100-octane gasoline.

About seven months after Farish's recommendations, Harold L. Ickes, then Petroleum Coördinator for War, now Petroleum Administrator for War, announced that the Nation's output of 100-octane fuel was to be tripled. This program was to be accomplished by building 50 new refineries at a cost of $150,000,000. On the day Ickes made this announcement, 100-octane gasoline production amounted to 40,000 bbl. per day with capacity for an additional 10,000 bbl. per day building. (In 1942 at least 16 different petroleum companies were making 100-octane aviation gasoline.)

The necessity for 100-octane gasoline becomes increasingly obvious when it is pointed out that after England entered the war her need for the fuel increased from 5000 bbl. per day at the outbreak to more than 36,000 bbl. per day. Russian requirements were at first negligible, but according to the last available reports are now more than 25,000 bbl. per day. The United States requires more than 50,000 bbl. per day for military use. In addition, high-octane fuels must be supplied to a growing Free French airforce and the Polish airforce. Thus, it may be seen that 120,000 bbl. per day capacity of 100-octane aviation fuel program was not excessive. After the original goal of 40,000 bbl. per day had been trebled to 120,000, it was increased to 180,000 bbl. two months later; a few weeks later this figure had become 250,000 bbl. per day.

Fluid Catalytic Cracking

Creation of a new refining technique, perfected by the Standard Oil Company, provides for the simultaneous production of synthetic rubber raw materials and an improved quality of 100-octane gasoline. This new process, fluid catalytic cracking, produces an improved base stock for aviation gasoline. In addition, the process is reported so flexible that it may be used actually to increase the output of 100-octane gasoline in some refining units.

Fluid catalytic cracking is regarded as the last word in modern petroleum refining. Basically, fluid catalytic cracking is a method by means of which oil is cracked into molecules that may be rearranged into many products. The catalyst speeds up and controls the chemical reactions. Raw materials for alkylates are made in these plants, which at the same time produce aviation gasoline base stocks. Despite the tremendous scale of operations of the fluid catalytic cracking plant, only nine men are required, more in case of emergency than for actual operation. There is little drama in operation of the plant—oil is fed through pipes to reactors, etc., and the catalysts to hoppers in freight carload lots. Among the important products of the catalytic crackers are the butylenes, produced in large quantities, which are subsequently converted into butadiene, a basic raw material used in the manufacture of the Buna synthetic rubbers.

At present the Standard Oil Company of New Jersey has two catalytic cracking plants in operation with five additional plants under construction. Under rights granted or technical information supplied by the company, the industry has some 26 catalytic cracking plants being designed or constructed, each costing about $6,000,000 to build. These plants will supply enormous amounts of blending agents for 100-octane gasoline and crude rubber constituents.

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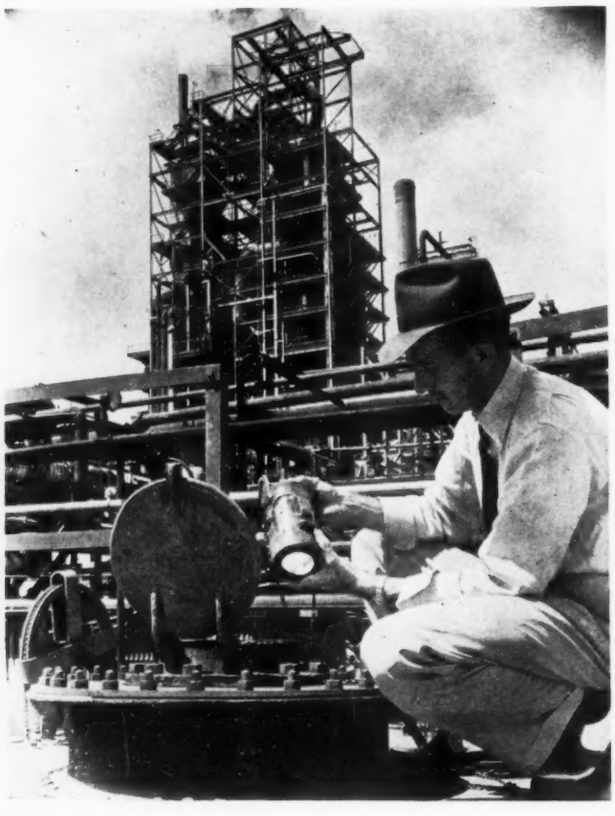
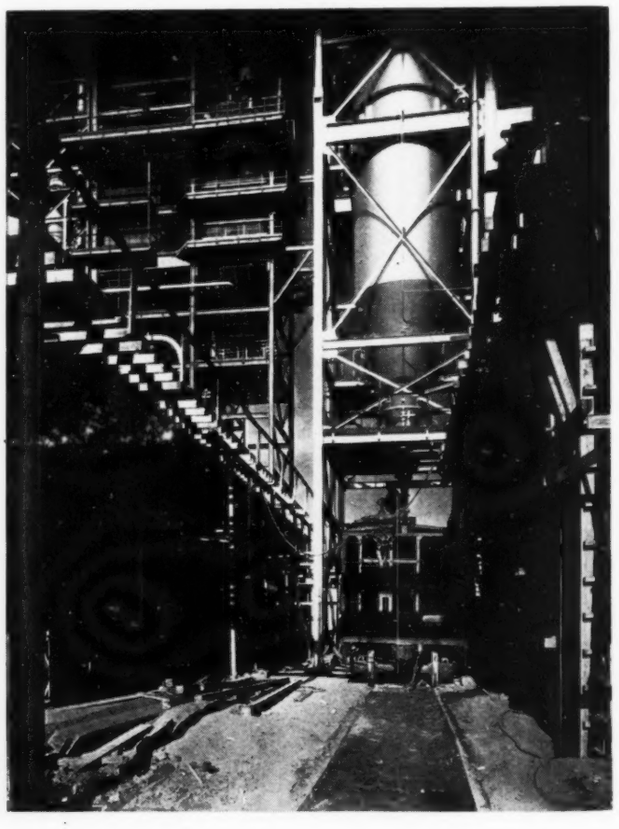
Aviation gasoline is made from selected crude oils. Operator below is shown sampling base stock through a gauge hatch. Some of the equipment for making 100-octane can be seen in the background



In modern petroleum refineries catalysts are used to speed chemical reactions. Catalysts are used in carload lots in this fluid catalytic cracking plant of Standard Oil Company of New Jersey



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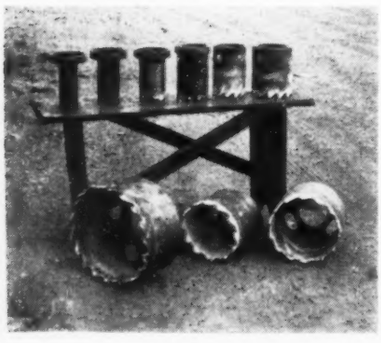
Shop Foreman,
The Farley Machine Works Company

THIS paper is submitted, not with the thought that it is covering any new ideas of design or any original application of arc welding, but rather to bring to attention what some of those old ideas mean to us out here away from the centers of engineering; to manufacturers, with their mass-production problems; and more especially to the tool industry, which is now carrying more than it has ever before been called upon to handle. The first thought of the writer is that any new application of an old idea is worthwhile. The thought in this paper is that whereas the application of a well-used idea of welding—applied, as in this case, to the "mostly scrap" material we had on hand—enabled us to do a hard job easily and quickly, there we had development.

A brief word concerning the small company by whom the writer is employed and the nature of its business. It has several small job shops or "contract shops" scattered through the oil fields of Kansas. The work consists of maintenance and repair of all kinds of oil-field equipment — drilling, pumping, treating, refining, and pipe line. Obviously, the three basic operations at each shop are blacksmith work, welding, and machine work. The old adage "Necessity is the Mother of Invention,"

[1]Data and illustrations from a study submitted to the James F. Lincoln Arc Welding Foundation by the writer, in its recent $200,000 Industrial Progress Award Program for reports on advancements and improvements made by the applications of arc-welding in design, fabrication, construction, and maintenance.

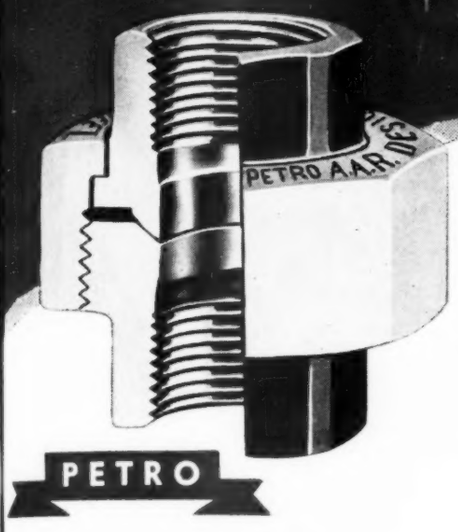
Mills, or cutters, after having been in service for several weeks



JOHN M. WILEY

attended the Oklahoma Agricultural and Mechanical College where he pursued a mechanical engineering course—He is shop foreman at Hutchinson, Kansas, for The Farley Machine Works Company, where he has been employed for the last 13½ years.

AMERICA'S FIRST LINE



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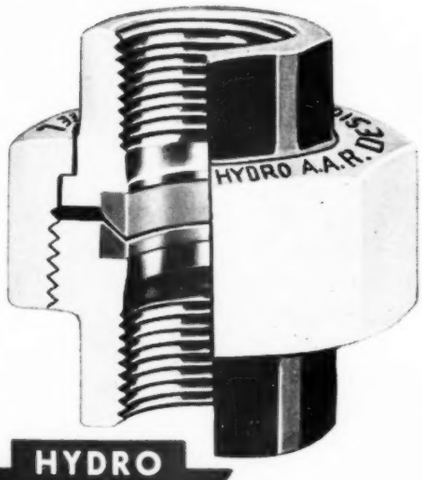

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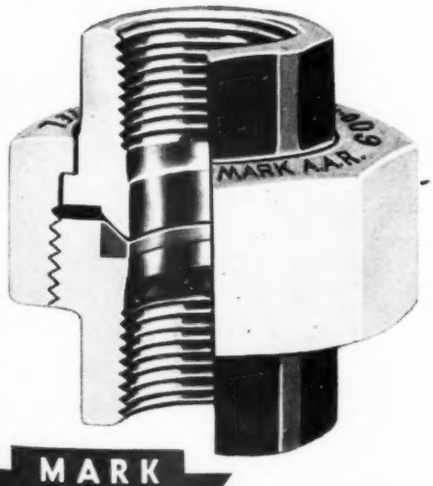

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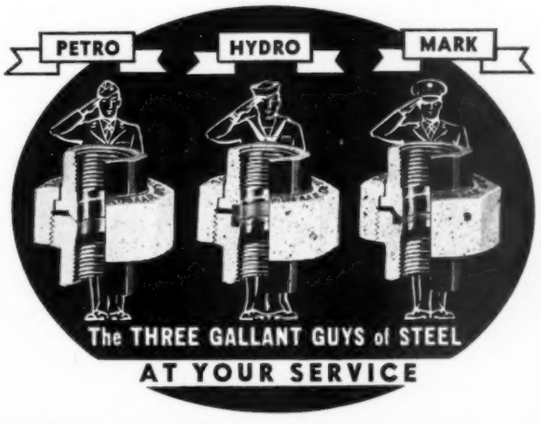
1150 lbs.	830 lbs.	630 lbs.	2000 lbs.	1150 lbs.	600 lbs.	400 lbs.	2000 lbs.



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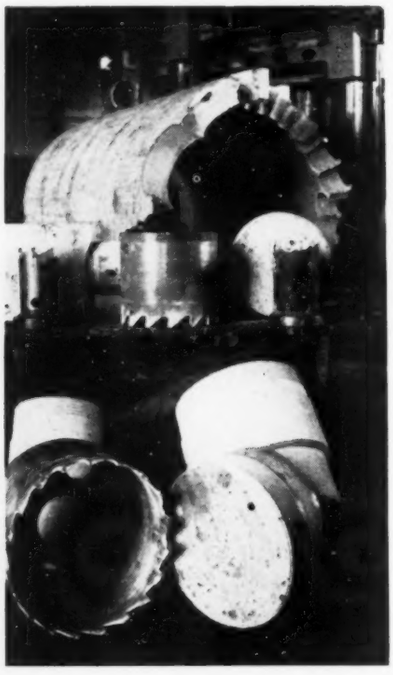

A close-up in the shop, showing several of the cutters, a few of the finished fittings, and in the background a piece of the "stock" from which the plugs and bushings are cut

was never more true than in a shop of this kind where at least every other job is "something different".

It has fallen to the writer's lot to have spent the last 20-odd years in this type of shop, the last 15 years in a foreman's capacity. This is the type of job where the foreman is called on to handle the personnel of from three to a dozen men, wait on customers, estimate or contract their work, "make" an occasional machinist or welder out of some inexperienced young chap, and during that time spend many hours making rough pencil or chalk sketches in lieu of an "engineering department".

Special Tools Needed

On or about February 1, 1942, the writer was asked to estimate and bid on a good-sized job of cutting, turning, boring, and threading Transite pipe. Transite is the trade name applied to a non-metallic and non-conductor material being used in pipe and many other fittings to combat corrosion, electrolysis, and tuberculation in oil-field and many other installations. The machining of this material is quite a job, due mostly to its abrasive character. Heretofore, this pipe had been joined almost exclusively by the use of Simplex Couplings—a Transite sleeve and two rubber rings—but this project called for all connections (tees, ells, bushings, plugs, and valves) being threaded to be screwed together. The shop problem was not only the cutting of holes for side outlets in tees, ells, and valves, but also the cutting of "stock to size" for plugs and bushings, ranging in size from 12 in. down to 2 in. in diameter. The stock for these bushings and plugs was sent to us in the form of 50-in. O. D. Transite pipe with a wall thickness of 5 in. Cutting these parts from this wall enabled the fiber or laminations of the material to give a maximum strength to the threads. The buying of hollow end mills of special sizes was out of the question, of course, not due to a prohibitive first cost, but to the fact that the tool industry would not, or rather could not, take time from national defense work for an oil-field industrial job of this kind.

Our thoughts turned to the welder, then, of necessity, to the scrap pile for material. Scraps of steel pipe, pipe couplings, pieces of steel plate, and junk shafting were cut and welded up into nine different sizes of millblanks besides several adapters for lathe and drill-press drives. In several instances it was necessary to build-up the end of the mill cylinder either on the inside or the outside in order to have the proper width of cutting edge and in two instances cut down the diameter of the cylinder by cutting out a longitudinal piece of the cylinder, drawing it down and welding it. A "standard" thread was assumed for all adapters and all mills, which made a careful lathe job easier. A lathe jig, carrying this same standard thread, was made on which all mills were screwed for turning and later for grinding. After turning and boring the mill cylinders, teeth were torch-cut, then hard-faced on front, inside, outside, and ends, then returned to the lathe where the hard-faced teeth were machine ground, with the proper clearance on all sides. Later it was found that an occasional grinding while the mills are in use is a small job, using this same jig.

In making these mills, a little "engineering" enabled more than one operation to be performed with one tool. For instance, the outside diameter of one mill cuts a hole to be threaded for 4-in. pipe, while the plug being cut is the right diameter to thread for a 5-in. valve stem plug. In fact, by varying the thickness or width of the cutting edges, 14 operations were accomplished with only nine tools.

Cost of Equipment

The cost of material used in these nine mills and their adapters can be compared to the price of so many lb. of scrap steel, outside of 3½ lb. of hard-facing metal that cost approximately $10.00. Three different kinds of hard-facing material were used. Obviously, by its length of service is known the material to use when it becomes time to rehard-face the tools.

Labor was as follows:

Torch cutting time	4	hours
Welding and hard-facing	8½	hours
Machine time	49	hours
Floor time	37	hours

Grouping all labor and material the completed mills, adapters, and jigs cost approximately $160.

There is no way to compare this job with any former one or with any other method of procedure, for, so far as the writer knows, this is the first time there has been needed exactly this kind of tool to fabricate or cut this particular type of material.

The problem solved was not only one of saving time and money, but of getting tools made that could not even be ordered under present circumstances and of "getting the job done". This is due, almost exclusively, to that modern method of joining metals—welding.

☆ ☆ ☆

Two of the mills with a lathe adapter and a drill-press adapter

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Manufacture of Lubricating Oils

Class Meeting No. 8

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils it usually denotes an interchange of discussion among the class members themselves.

Leader: I believe the subject of mixed solvents probably follows along the avenue that would be expected. If desired results are not obtained with straight solvents and it appears that mixing would improve the results, that would be the logical step. This chapter[1] gives a number of different mixtures that have been found to be helpful, however, most of them have not reached any commercial stage. Note the variety of elements and compounds that have been utilized. There is one previously discussed; the liquid sulphur dioxide and benzol process. There is another that Foster Wheeler Company has been developing. This is the one using crotanaldehyde and acrolein. (See Table 9). Further information was given to the effect of substituting water for acrolein. The names used, that are worthy of remembering, is the product called primary solvent, very logically, and then the second product is called the secondary solvent.

Pupil: It is possible for either one to change during the process, isn't it? That is, in the solvent treating in the refinery. The primary and secondary solvents might change and the secondary solvent might become the primary.

Leader: I think that would be very probable. It seems reasonable that this might occur. What are some of the reasons for mixing? If you had a mixture such as in the phenol extraction process with too much solvent and the selectivity seemed to be favorable—may you add water? What happened to the phenol? Why was water added to the phenol?

Pupil: To decrease its solubility.

Leader: Evidently it has been too violent for a certain oil, so that method was used to remedy the difficulty. Any other comments on mixed solvents?

Leader: As an introduction to Chapter XIV, would you assist in interpreting this flow diagram? (Fig. 15.)

Pupil: The Duo-Sol Process handles practically any kind of charge and our problem is long residuum. Raw stocks are picked up and pumped into a mixer. In the mixer countercurrent flow is set-up.

The main solvent is pumped in at No. 7 extractor. This main solvent is a mixture of cresylic acid and phenol and has the trade name "Selectol." (See Table 10). Our group figured we would have to use about 300 percent solvent to obtain a 95 viscosity index oil. This countercurrent flow comes from the No. 7 extractor. Stock is induced at the No. 3 extractor and propane induced to No. 1 extractor. The runs are immediately picked up and transferred into this mixer where countercurrent flow enters from the black strap layer. In order to dispose of it, the paraffinic layer is taken off to solvent recovery where any entrained propane is flashed off and the "Selectol" is recovered. The propane is treated and recovered in the same manner and this simplified flow is followed through all extractors, raw stocks being used at the No. 3 extractor. The Duo-Sol people, in an article that appeared in the June, 1935, issue of *The Refiner* by M. H. Tuttle, of the Max B. Miller Company, compared this to a fractionating tower, inasmuch as there is a fractionation and a stripping action as in a fractionating tower; extracting what little of the paraffinic layer that is left in the waste layer in the No. 1 and No. 2 extractors, and then performing what might be called fractionating in the other 5 vessels.

Leader: There is probably some precipitation of asphalt due to the use of propane. What are the temperatures? Approximately atmospheric? I believe our book shows 60 to 90°F., so then the asphalt propane mixture comes over and is joined by the fresh propane. What happens with the first propane? Is it used to scrub the "Selectol?"

Pupil: Yes.

Leader: Why?

Pupil: To pick up more oil.

Leader: Evidently it is a necessary economy measure.

Pupil: The wax is not soluble in the propane. How would the propane pick up the wax that precipitated with the asphalt?

Leader: I think there is a separation; the wax goes into the propane phase at that stage.

Pupil: It would seem that paraffin precipitated with the asphalt would possibly be some type of paraffin that would not readily be gotten in with the propane again with the raffinate. Would that be the case?

Leader: Yes, I think we discussed that before and did not completely answer the question. Suppose we are treating a light wax distillate, and had come through with the cresylic acid and are about ready to discharge, but make a couple of washes with propane. Do you think you would get it out? What would be the results?

Pupil: I think it could be gotten out all right, but I do not understand the physical change that takes place.

Leader: The wax solubility proposition is at low temperature.

Pupil: The text says that is one reason for operating at that temperature and, although it doesn't say, I thought that on some oils it would be necessary to dewax before treating in this manner.

Leader: Possibly. In the problem for tonight it has been stated as unnecessary.

Pupil: As far as the viscosity index

TABLE 9

Properties of Crotonaldehyde and Acrolein

	Crotonaldehyde	Acrolein
Chemical formula	C_3H_5CHO	C_2H_3CHO
Molecular weight	70.07	56.05
Boiling point	218°F. (103.3°C.)	126.3°F. (52.4°C.)
Freezing point	—103°F. (—75°C.)	.....
Specific gravity at 68°F. (20°C.)	0.859	.....
Viscosity, centipoises at 85°F	0.539	.....
Viscosity, S. U. V. 100°F	31.5	.....
Vapor pressure, mm.Hg. at 100°F	80	.....
Specific heat	0.50 B.t.u./lb./°F.	.....
Latent heat of vaporization	214 B.t.u./lb.	
Flash (closed cup)	44°F.	

This table appears as Table 37 on page 153 of the text.

[1]Chapter XIII, Modern Methods of Refining Lubricating Oils, Vladimir A. Kalichevsky.

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number is concerned, one laboratory at least has a hexane dewaxing system that will obtain the original viscosity index. It is possible to start with a viscosity index of from 110 to 112, and get it back to 98 to 100.

Leader: Do they test the raffinate?

Pupil: Yes.

Leader: What kind of pressures would you want on that system? What would be the limiting factors? Would the wax—temperature of the solution—limit the low temperature range?

Pupil: It would have a lot to do with it.

Leader: This temperature will be nearly as low and still obtain the extracts from the "Selectol" at this point. It seemed to me that that must be the way it would be governed. The pressure would be higher then; therefore, the operating pressures will be governed by wax in one instance, and the vapor pressure of the propane solution in the other.

Pupil: One article stated that the raffinate went into the flash tower at 250-lb. pressure.

Leader: Would you get the idea that these vessels were operating under that pressure?

Pupil: Yes.

Pupil: Vessels operate at a temperature from 105 to 110°F.

Pupil: He is talking about actual operation.

Leader: That is what we want.

Pupil: Would that require a pressure of 300 lb?

Pupil: The actual is 215 lb. The 300-lb. figure might be a design figure.

Leader: We will say 300-lb. design and maybe 215-lb. operating pressure. We will all agree that those pressures are going to be subject to the wax situation and it is quite conceivable that some of the charging stock will have waxes that will make it necessary to dewax before operation.

Pupil: The author states that low temperature is to be avoided due to emulsification difficulties. A table shown in this original article gave a list of several charging stocks that were handled in the pilot plant. One of these examples lists a Panhandle Overhead (Dewaxed), and I believe that it might be necessary to dewax some stocks that have a high percentage of wax.

Leader: Do you remember some of the Panhandle crudes? Shipments of that crude oil, ordered by certain refineries, were transported in box cars. Probably that material would be below the range of satisfactory treating. What is your idea regarding the yields that would be obtained on the stock we propose?

Pupil: The yields vary considerably.

Leader: Group No. 1, what kind of yields do you have?

Pupil: 74 to 77.8.

Leader: Group No. 2?

Pupil: We decided on 75 percent with 95 viscosity index number.

Leader: Group No. 3?

Pupil: 70 percent undewaxed or 35 percent dewaxed.

Leader: Group No. 4?

Pupil: We have an actual 98 to 100 viscosity index ranging from 70 and 80.

Leader: Group No. 5?

Pupil: We figured 83 percent.

Leader: You get the contract.

Pupil: Yes, but there is a catch to ours. We assumed that the long residuum would have a 75 viscosity index to start with. We assumed 42 percent—down to 22°A.P.I. to save our good wax.

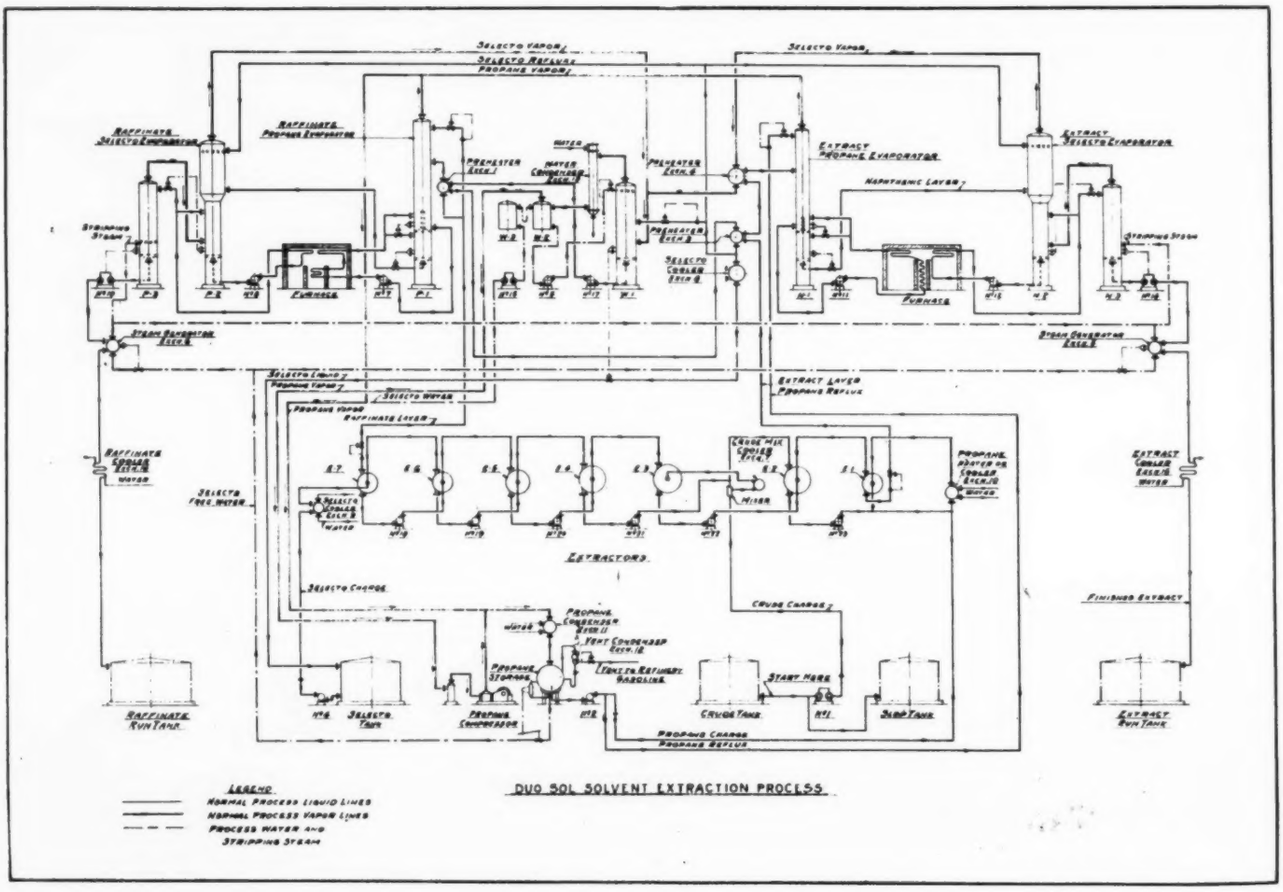
Leader: What method did you use to get that yield?

Pupil: We decided that a good engineer never guesses—he always estimates.

Pupil: We used a group of tables and selected one that fitted our problem, then figured an average between all of them.

Leader: Our group used the curve and

Fig. 15. Duo Sol Solvent Extraction Process



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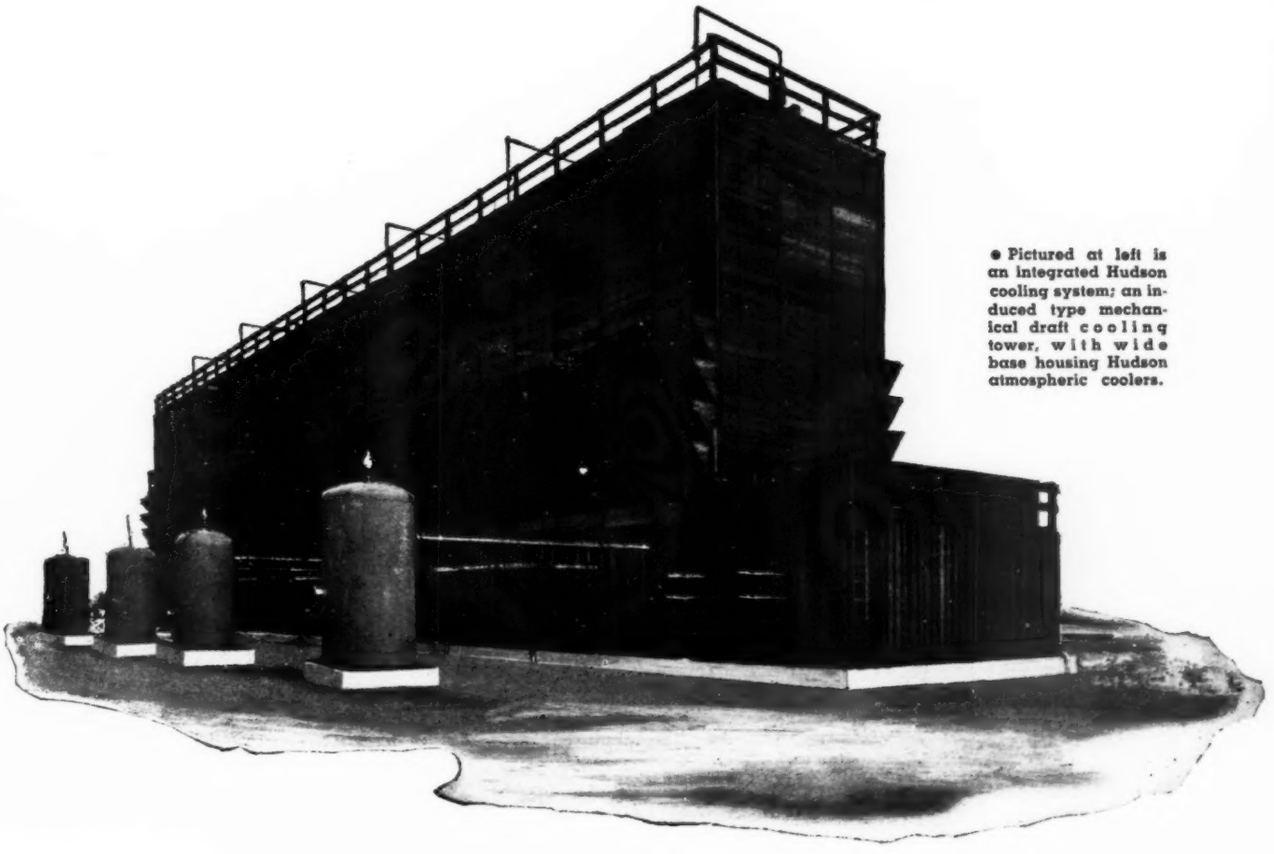

• Pictured at left is an integrated Hudson cooling system; an induced type mechanical draft cooling tower, with wide base housing Hudson atmospheric coolers.

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with some calculations arrived at our figure. We began with a 75 viscosity index number, which is a very choice Oklahoma City residuum.

Pupil: What type of cut did you take off on the vacuum unit?

Leader: Long residuum.

Pupil: You took a high wax cut off there?

Leader: No, we assumed the cut complete. Supposing that you had gone to the use of a vacuum unit, an overhead cylinder stock made, and the overhead cylinder stock charged through this system. In the discussion of the Duo-Sol Unit there was mention regarding the possible difficulties. Would you anticipate any trouble?

Pupil: Would the wax give you more trouble?

Leader: Do you have any history on that subject? On page 155, in the text, the second paragraph under "Paraffinic Solvents" states:

"Although paraffinic solvents are generally considered to have preferential solvent action toward the desirable oil constituents, this is, apparently, open to question, particularly in the absence of asphalt."

I don't know whether asphalt would be considered absent, but the general comment has been made by some operators that the presence of asphalt is really desirable but indications are that there may be some difficulties, and that statement would perhaps point the way, as mentioned, to lessen the quantity of the asphalt. If such were the case, it appears that those operators who have used the Duo-Sol Process have ended by using residuum oil. Do any of you know any vacuum overhead distilled products that are being refined by Duo-Sol? Why do you think it might be better to run an oil through this Duo-Sol process rather than vacuum distill?

Pupil: It probably increases the yield of heavy lubes; vacuum distillation ends up with tar.

Leader: This tar is a decidedly interesting subject. In several instances, the work that has been done has given some rather interesting results that we will discuss later.

Pupil: How about the color factor?

Leader: Separation by this process is reported to give a better color.

Pupil: I am of the opinion that when you begin refining Oklahoma City residuum to 100 viscosity index number, you are going to have to use a little dye in the lubricating oil to obtain a conventional color.

Pupil: I think they are getting an exceptionally good color.

Pupil: What do you mean; light color?

Leader: A few customers have an idea that bloom means something; the light oils do not have so pleasing a bloom.

Pupil: The oils produced by this process differed very little from our conventional color.

Leader: The oil is filtered—the colors are improved with regard to bloom.

Pupil: I do not mean that the bloom was improved particularly, but the actual color of the oil. The samples we observed were taken from actual solvent treating operation and compared favorably with the samples from our own operations.

Leader: The raffinate from this may be as light as 1½ NPA, which is a very high degree of decolorizing.

Pupil: We have a gravity reduction that is rather interesting, and it might be well to compare it with the actual gravity obtained on the tar in the vacuum unit. I think the loss in reducing 22-gravity residuum is about 8½ A.P.I. gravity.

Leader: Which is above the specific gravity. This extract then is what?

Pupil: I think about 12 from vacuum distillation.

Pupil: It is lower than that in the above one.

Pupil: Residuum is about 25 to 26, and the vacuum tar is reduced to a gravity somewhat comparable.

Pupil: Speaking about bloom—do you consider that the same as the cast?

Leader: Yes.

Pupil: Specific gravity of this naphthenic layer is given as 1.03.

Pupil: It is about 8½, although the vacuum unit tar was about 12.

Leader: It is not ordinarily.

Pupil: We used to run those under control and had to make salt solutions.

Leader: How do you estimate the gravity?

Pupil: I do not remember, but it is heavier than water.

Leader: I had in mind around 7 or 8 gravity.

Pupil: I think that is about right.

Leader: It seems to be pretty close. Is that the naphthenic layer or extract from that layer?

Pupil: The extract.

Leader: Do you recall the characteristics of your cresylic acid? It has a boiling point of 390, I believe.

	Cresylic acid	*Phenol*	*Propane*
Boiling point	365-400	361	—44
Sp.gr.68/68°F.	1.045	1.072	0.511

What causes the variations in the amounts of phenol used? Isn't that one of those mixed solvents that is varied? How about propane? Does this family have quite a strong solvent power? Would you expect it to have a high solvent power?

Pupil: Yes.

Leader: What happens to the phenol again?

Pupil: The cresylic acid usually contains from 20 to 40 percent phenol as naphthenic solvent.

Pupil: Is phenol being used to increase the selective power or to decrease the solvent power of cresylic acid?

Pupil: The mixture of phenol and cresylic acid for the naphthenic solvent permits adjustment of its composition to allow extraction within the desired temperature range.

Leader: What are the results in the variation of the amount of propane that is used? Referring to Table 11, with 100 percent cresylic acid and 200 percent propane, there is an 86 percent yield of 84 viscosity index number. What is the result of keeping the cresylic acid percentage the same and increasing propane to 600 percent?

Pupil: The yield is increased and the viscosity index number is decreased.

Pupil: You would produce less of the undesirables.

Leader: Do you think that the propane removed the acid? You must have a strong solvent power, so that when more and more propane is obtained, extraction of the cresylic acid is started and the oil is taken back out. You have 100 and 200 percent by weight cresylic acid, respectively, and then increase to 300, leave the propane alone, and what happens?

Pupil: The yield goes down and the viscosity index number goes up.

Leader: Then you go up to 300 and 600 percent and leave the cresylic acid alone and you have a repetition of the same result as at first. It would appear that there is a considerable flexibility possible between the selectivity and solvent power by varying these ratios. Has this been made clear to everybody? Are there any questions?

Pupil: I suppose then that the pri-

TABLE 10

Properties of Cresylic Acid and Cresol

	Cresylic acid	Cresol (mixture of meta- and para-)
Chemical formula	.....	$C_6H_4(CH_3)(OH)$
Molecular weight	.....	108.10
Boiling point	365—400°F.	396°F.
Specific gravity at 68/68°F	1.045	1.035
Specific heat, B.t.u./lb./°F	0.53	0.525
Latent heat of vaporization, B.t.u./lb	180	178
Flash point (closed cup)	.....	186°F.
Boiling point at 100 mm. Hg	.....	281°F.

This table appeared as Table 38 on page 158 of the text.

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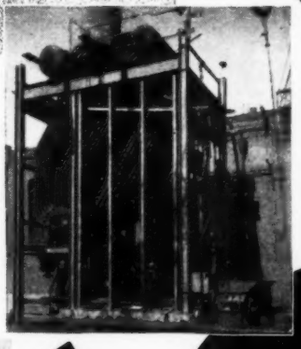

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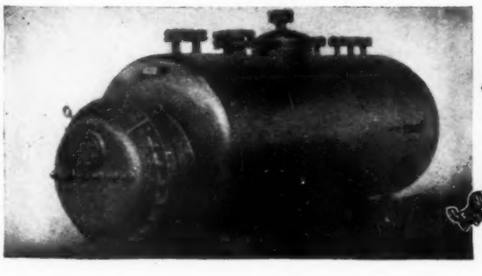

To Combat Corrosion and Product Contamination

Process equipment made from special metals and alloys for the exacting service of the chemical plant is fabricated in our modern shops for many of the well known chemical companies.

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Our experience of more than 50 years in building profit-making ice and refrigerating machinery is at your command. We make complete units for ice and cold storage plants, packing plants, dairies, breweries, chemical plants, oil refineries, etc.

TABLE 11
Duo-Sol extractions of Mid-Continent Residuum

Percent weight of solvents employed		Raffinate yield (percent volume)	Properties of dewaxed raffinate			
Cresylic acid	Propane		Viscosity index	Carbon residue	Color Lovibond (¼ in. cell)	S.U.V. at 210°F.
100	200	86	84	1.1	525	115
100	600	90	77	1.0	260	124
300	200	74	96	0.5	325	104
300	600	81	91	0.5	165	103

This table appears as Table 40 on page 160 of the text.

mary purpose of the process is removing asphalts?

Leader: Yes. You would infer that the presence of propane at these temperatures would do some deasphalting so this gives two stages of the process, deasphalting and de-resining.

Pupil: How is the oxidation stability?

Leader: Very good, in general. What would be the inclination on refining these oils to a given viscosity index number or oxidation values?

Pupil: I would say good oxidation number at the present time and a few years ago it would have been viscosity index.

Pupil: I think they usually go together.

Leader: Apparently so. For good oxidation values you probably will have 90 or above viscosity index. In some other areas you would have something under that. That brings us back to the probability that we will still have a considerable interest in the geography of the crude oils. Some people thought solvent refining was going to eliminate the factor of geography.

Pupil: There is a top limit on the viscosity index, however.

Leader: What is the top level?

Pupil: Removing inhibitors. Oxidation inhibitor and stability inhibitor.

Leader: I think that it is proper to state that each process has its merits and there are going to be many different processes developed in the future. Let us have the next group.

Pupil: Several times reference has been made to the work that Dr. Frederick Rossini has done. Some groups were trying to find out just what lube oil was composed of, and so split it up. Rossini worked with a lube fraction from a Kay County crude—the fraction being the upper 5 percent of a 12.5 percent residuum and the lower 5 percent of the lube fraction. The above percentages are based on crude. Considering the above 10 percent as 100 percent of the oil under observation, the split-up was made as follows: 35 percent wax, 35 percent water white oil, 22 percent extract, and 8 percent asphalt. The methods of separation will not be considered here.

Composition and characteristics of the four separated groups of oil are explained in Table 12. That group of molecules in the water white oil had a viscosity of 100-500 at 100 Saybolt and the viscosity index number ranged from 90 to 110. That was the reason for my statement that probably this oil that they were refining to 100 viscosity index number was rather a light color because in that portion of his lubricating fraction he only gets 90-110. The 100 percent is the lube fraction and would be comparable to a portion of wax distillate, all of the heavy wax distillate, and a portion of overhead cylinder stock from a vacuum operation, and the finished oil with a viscosity at 210 is about 30-35 seconds. Note that viscosity index on the 22 percent lube extract fraction was minus 80 to minus 150, which is rather low. He has taken out the molecules with 3 aromatic rings and one naphthene ring. We were talking about removing aromatics. You can see just what that does. He did not state specifically, but he did say that if a molecule contained one naphthenic ring and 3 aromatic rings that the viscosity index would be a minus 1600 if the number of carbon atoms in the side chains was 5. Reference was made one time regarding the possible use of a pressure still product as a source of lube oil. Cracking does away with this paraffinic side chain and from the cracking process you probably would not have a chain, therefore, a very low viscosity index. That takes care of the molecule with 3 aromatic rings and if the molecule has two aromatic rings with 7 carbon atoms in the side chains you still have a minus 365 viscosity index number, so that is still low. There is only one other fraction on which I have the individual viscosity index number, and that is the 2 naphthenic rings and one aromatic ring. The viscosity index number is 35. The carbon atoms in the side chain were 14, so you can see the significance of an oil being paraffinic from that. In the 35 percent wax, someone mentioned that it is quite a large percent, but 17 percent to 9 percent of this consists of molecules of 1, 2, or 3 naphthenic rings. You can see that a large portion of this first cut is the same type molecule, but he explains the fact that they are in this wax portion by reason of the fact that the melting point is not determined by the type of molecule, but on its symmetry. So undoubtedly these in the water white oil are not symmetrical. The other portion of the wax was 18 to 26 percent paraffin and possibly *iso*paraffin. This chart to me definitely proves we want to get rid of aromatics.

Pupil: By hydrogenation you can possibly increase the yield from 35 to 57 percent and still remove the same amount of wax. If this wax could be split up, the normal paraffines and 1, 2, and 3 naphthenic rings, then the pour point on the 1, 2, and 3 naphthenic rings could possibly blend this back up here in the water white oil and raise the viscosity index number above this figure (90 to 110.)

Leader: Did he bring out that the n-paraffins are crude scale waxes and *iso*paraffins are amorphous waxes?

Pupil: He did not bring that out, but I assume that is true.

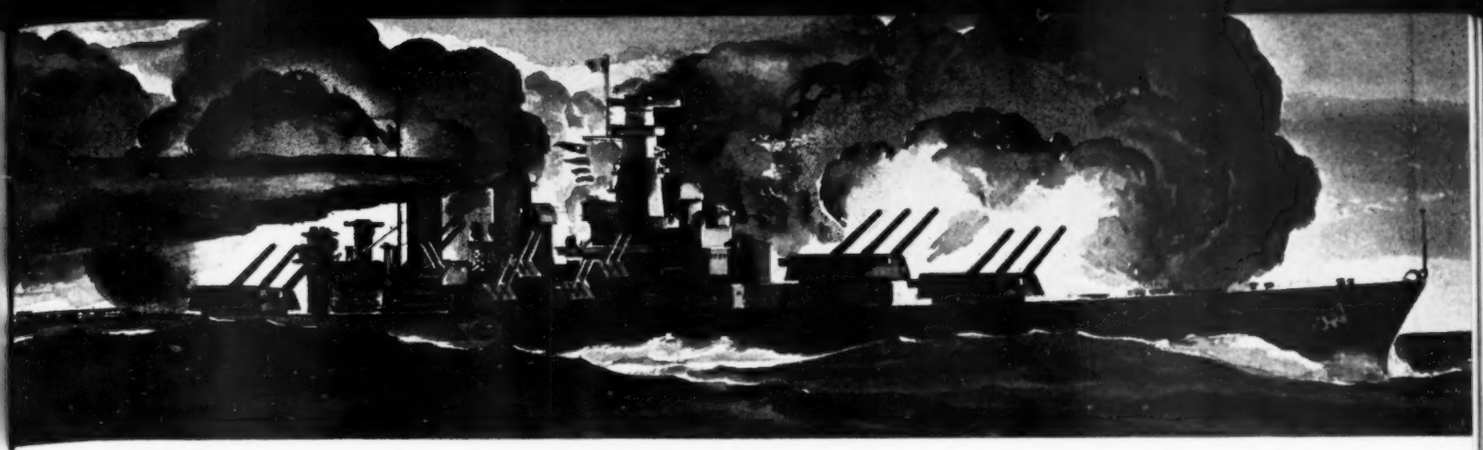
(To be continued)

☆ ☆ ☆

TABLE 12

Water white oil	35 percent	1 Naphthene ring +paraffin groups	5.3	Viscosity 100 to 500@100 V.I. 90 to 110 31 to 26°A.P.I.
		2 Naphthene rings +paraffin groups	15.7	
		3 Naphthene rings +paraffin groups	11.2	
		1 Naphthene ring +1 aromatic ring +paraffin groups 2 Naphthene rings+1 aromatic ring +paraffin groups	2.8	
Intermediate or extract	22 percent	2 Naphthene rings +paraffin groups 3 Naphthene rings +paraffin groups	1.1	Viscosity 1000 to 9000@100 V.I. −80 to −150 12°A.P.I.
		2 Naphthene rings+1 aromatic ring +paraffin groups 3 Naphthene rings+1 aromatic ring +paraffin groups	5.5	
		2 Naphthene rings+2 aromatic rings+paraffin groups	8.1	− 35 − 365 7C −1600 5C
		1 Naphthene ring +3 aromatic rings+paraffin groups	6.6	
Wax	35 percent	1, 2 or 3 Naphthene rings +paraffin groups	17 to 9	
		N-paraffins+possible iso-paraffins	18 to 26	
Asphalt	8 percent	No data	8%	

Naphthene rings	Aromatic rings	C in side chain	Viscosity, S. U. @ 100°F.	Viscosity, S. U. @ 210°F.	Viscosity index	
1	3	5	410	30	−1600	¼ C's in side chain
4	0	5			− 300	
2	2	7			− 365	
4	0	7			− 150	
2	1	14			35	½ C's in side chain
3	0	14			40	



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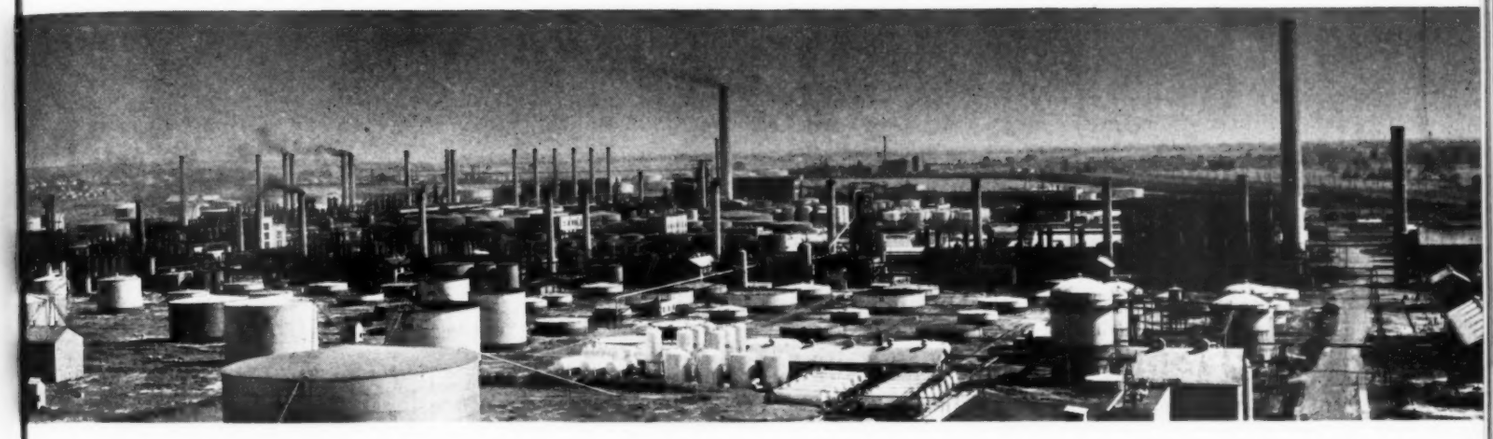

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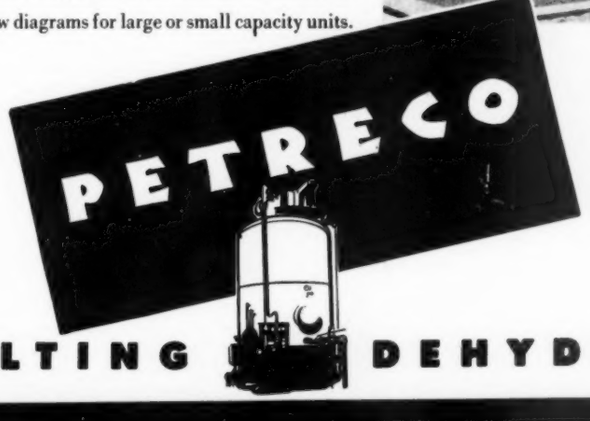
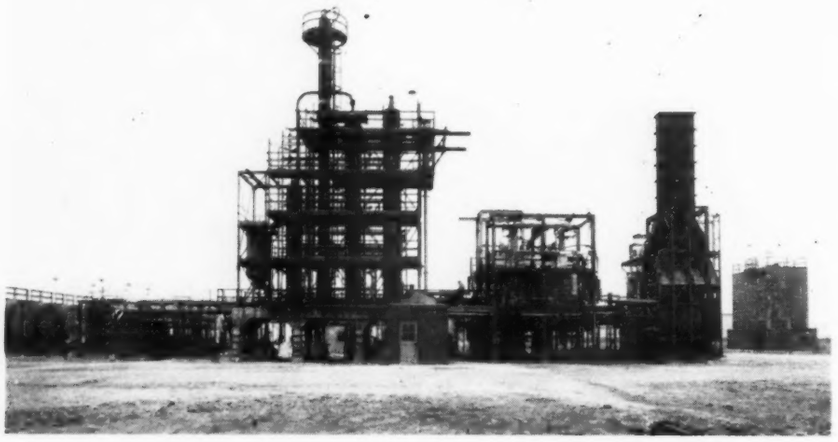


DESALTING DEHYDRATING

P 751.2



General view of Phillips' catalytic unit where Cycloversion was developed. Catalyst chambers are between towers and heater

Cycloversion Process Produces Ingredients For Aviation Gasoline

☆ Naphthas resulting from thermal operations converted catalytically to aromatic rich stocks

CYCLOVERSION is a process developed and recently announced by Phillips Petroleum Company for the manufacture of high quality aviation fuel ingredients. Naphthas produced in thermal operations are converted catalytically to aromatic rich stocks for use in aviation gasoline.

The necessity for maximum development of catalytic conversion processes at this time is obvious. Better fuels make possible the development of better engines. The extension of fighting fronts to all parts of the globe is demanding from the industry enormously increased quantities of aviation fuel. The Cycloversion process helps on both counts, for it not only aids in meeting the increased quantity demand but also can provide aviation fuel much superior to present-day 100-octane.

After years of laboratory and pilot plant investigations, the company installed, at one of its refineries, a new unit incorporating the many unusual design features of Cycloversion. Operation of this unit has verified the results of the earlier and continued small-scale experimentation. It has also supplied the necessary engineering data for large Cycloversion units that embody many new features of design and operation.

An outstanding feature of the process is the extensive production of aromatic hydrocarbons in the gasoline boiling range, resulting from Cycloversion of a selected gasoline or naphtha type charging stock. The extent of cyclization is demonstrated by the fact that aviation gasoline fractions may be obtained containing up to 90 percent of aromatics with very small amounts of olefinic unsaturates. The principal by-products include butylene and *iso*butane, which are valuable as alkylating agents. Conversion is accomplished with high process efficiency.

In the course of studying process variables, the Cycloversion unit has been operated on stocks ranging from light gasolines to heavy gas oils. For aviation stock preparation, excellent results have been obtained by processing selected naphthas derived from gas oil or topped crude thermal cracking or from gas reversion operations. Maximum yields of high quality gasoline are obtained, along with valuable gaseous by-products and minimum dry gas and carbon. These results are accomplished by adjustment of the conversion conditions (temperature, pressure, concentration, contact time, and cycle length) to suit the quality of the charge whose characteristics will vary with source, boiling range and previous treatment.

Description of the Process

Cycloversion involves passing the feed through a conventional heater where it is vaporized and raised to conversion temperature. The design of the furnace and the method of operation provide for control of thermal decomposition. The heated vapors pass through the catalyst chamber at moderate pressures and at relatively high flow-rates. Processing of the charge is made continuous by the alternate use of two or more catalyst chambers. Reactivation of the catalyst is accomplished by controlled burning of the carbonaceous material that accumulates during the processing of the charge.

The length of the process period depends upon the characteristics of the charge stock and the desired depth of conversion. Typical process periods during the production of high quality aviation stocks range from one to five hours. This provides ample time to permit the use of very simple control equipment in alternating the catalyst chambers between process and reactivation.

Catalyst

Cycloversion catalysts are characterized by long service life and resistance to poisoning. Steam is used in both the process and reactivation steps without injury to the catalysts. Simplified and rapid reactivation is made possible by the ability of these catalysts to withstand high temperatures.

Features of Process

Cycloversion has many features, among which are:

1. The simplicity of the fixed catalyst bed.
2. Simplicity of design and ready convertibility of existing refinery facilities, which permit substantial savings of critical materials.
3. Long process periods.
4. Rugged, long-lived, and inexpensive catalysts.
5. Precise process control.
6. Flexibility with respect to charge stocks and products.
7. Low investment and operating costs.

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ALL THESE FEATURES . . . .

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Originally made slightly oversize, the Midwest Elbow is then reheated and reduced to accurate size and shape in dies which *compress* the metal at a forging heat—it is not extruded or stretched.

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and true circular cross section are inherent advantages resulting from the unique manufacturing process.

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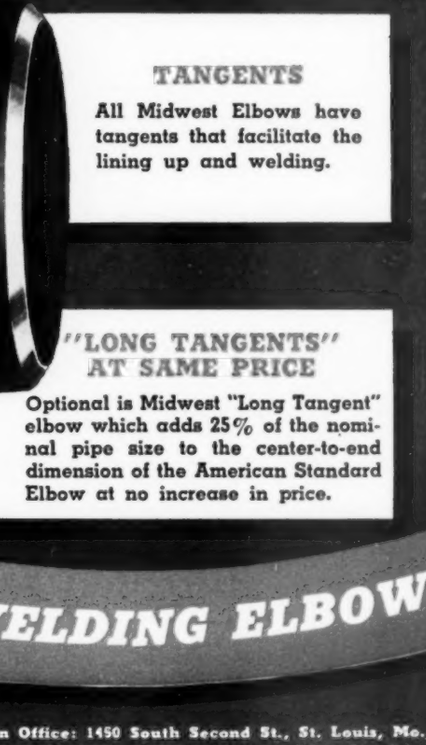
Reheating to a forging temperature normalizes both the plate and the weld, relieving the stresses set up during the forming and welding operations.



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PART 2 (Concluded)

by Henry N. Wade
President, Parkhill-Wade

Diethylene glycol solution plants. The first two plants using this material went into operation in January, 1937. The operation of one of these plants at an average pressure of about 400 lb. shows a total consumption of glycol of 0.22 lb. per 1,000,000 cu. ft. of gas treated. The other plant operating at a somewhat lower pressure shows a consumption of 0.501 lb. The corresponding costs including operation, maintenance, glycol make-up, and prorated fuel are 31.6 cents and 32.9 cents per 1,000,000 cu. ft. treated, respectively.

This operator reports no troubles with corrosion in any part of the system, but states he found it desirable to install filters in the solution stream to keep the solution free from foreign materials.

The same operator reports extremely satisfactory operation of a combination dehydration and hydrogen sulphide removal unit using a mixture of monoethanolamine and diethylene glycol under the Girdler patents. No figures regarding operating costs are given for this unit.

Another diethylene glycol plant operating at an average pressure of about 300 lb. per sq. in. with gas temperatures running greater than 90° under heavy load conditions reports an average glycol consumption of 0.811 lb. per 1,000,000 cu. ft. of gas processed during 1942. The solution circulating pumps in this plant are of the packed piston-type, and the operator states that they have had persistent trouble in maintaining the packing rings on the pistons. This experience brings out the fact that packed piston-type pumps are generally not satisfactory for this sort of service, and that the plunger type is to be preferred.

This operator reports no difficulties of any kind resulting from corrosion or glycol decomposition. Inspection of the reboiler case last summer disclosed a considerable deposit of a black gummy substance on the lower head of the vertical reboiler unit, but there was no apparent fouling or clogging of the reboiler tubes themselves.

The largest dehydration plant using diethylene glycol solution was changed over from operation using refrigerated calcium chloride brine to operation with the glycol solution late in 1940. This plant operates at an average pressure of about 500 lb. An exceptionally low overall loss of glycol solution is reported, averaging slightly under 0.25 lb. per 1,000,000 cu. ft. of gas processed. No other separate cost figures are kept.

Completely automatic diethylene glycol dehydration plant. Capacity, 60,000,000 cu. ft. per day at 1000-lb. pressure

A puzzling and not yet fully explained case of corrosion was experienced in this plant. In the hope that the experiences with corrosion there may be of value to other operators, the conditions are reported rather completely as follows.

Within a few months after the plant was placed in operation the seamless steel tubes in the solution heat exchangers failed through corrosion. Investigation of the products of corrosion showed cakes of black material consisting of ferrous oxide and iron sulphide. As the gas contains small amounts of mercaptans, but no detectable traces of hydrogen sulphide, it was concluded that the formation of the sulphide of iron must have been caused by the decomposition of mercaptans through the agency of heat and the action of some unknown catalytic material in the system.

Before the occurrence of the active corrosion was discovered the still base temperature had been maintained at about 320°F. Acting on the theory that the conversion of mercaptans into hydrogen sulphide might have been caused by this exceptionally high still temperature, the control point was lowered so as to carry the still base at about 280°F. At the same time the pressure on the still was lowered from 10 lb. to 3 lb. gauge.

Before this change was made the overhead vapors from the still had consistently given a positive test for the presence of hydrogen sulphide, but after this change in still operating conditions the hydrogen could no longer be detected.

In order to make sure that the comparatively slight change in still operating conditions had removed the cause of the corrosion, a one month's trial run was then made with the still base temperature maintained at 290°F. Toward the end of this run the glycol began to turn black, showing signs of the formation of iron oxide and sulphide. Upon again lowering the still base temperature to 280°F. the glycol cleared up after about a week of operation at the lower temperature.

Similar corrosion was experienced with the admiralty bronze tubes in the still reboiler. In this case the corrosion

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was nearly uniform over the entire area of the tubes, so that they became so thin as to collapse finally under the external steam pressure before any pitting had occurred. This is the first example of corrosion of this kind that the writer has seen.

The above operating experience offers an interesting field for investigation, which will be undertaken when opportunity affords. In the meantime, if corrosion is encountered in systems where mercaptans are present in the gas the points brought out may provide a method of controlling it.

Combination sulphur removal and dehydration plants. A report from one of these units using a mixture of monoethanolamine and diethylene glycol solutions shows the following general facts: The plant has been in operation about 15 months treating gas containing 900 to 1000 grains of hydrogen sulphide per 100 cu. ft. The gas is desulphurized and dehydrated to dewpoints of approximately 35°F. in a single contacting tower. Quantitative determinations of hydrogen sulphide in the outlet gas show negative up to a maximum of 0.2 grain per 100 cu. ft.

No corrosion or other operating troubles have been reported.

The very large amount of hydrogen sulphide removed from the gas is the equivalent at full load of about 14,000 lb. per 24 hours of sulphur. The safe disposal of this large volume of poisonous gas is accomplished by burning it at the top of a mast about 100 ft. high. The sulphur dioxide resulting from the combustion is diffused enough to cause no difficulties around the plant.

Solid adsorbent type plants. We have several reports from plants using Florite and activated alumina that give only general overall operating results without costs or other details. The oldest of these plants with which we are familiar went into operation early in 1940. The owners report entire satisfaction with the operation and state that the original bed of Florite appears to be good for an indefinite service. The substance of these general reports indicates that the two forms of alumina now available for this purpose offer the most satisfactory performance that has been obtained by solid adsorbents.

Miscellaneous Data

Five graphs are presented with this article, providing the basic information required for the rough design of the hygroscopic solution type plants. Similar data bearing on solid adsorbent type plants are given.[2,16] The writer's experience with plants of this type is not yet complete enough to permit addition of other material to the information contained in these references.

Fig. 3 presents a chart showing water vapor content of natural gas consisting principally of methane and other paraffin hydrocarbons that has been prepared from a study of the papers by Laulhere and Briscoe, and by Deaton and Frost.[12,22] Laulhere and Briscoe reported in the Fall of 1939 on an investigation to determine the effect of pressure on the water-carrying capacity of natural gas, finding that the water vapor content of a typical California natural gas at 60° F. under a pressure of only 500 lb. per sq. in. gauge showed a water content about 31 percent higher than it would have contained had the gas and water vapor followed the ideal gas laws. At the same pressure and a temperature of 110° F. the water vapor content was still about 20 percent above the amount indicated by the gas laws.

Deaton and Frost carried similar investigations by a different method up to pressures slightly over 600 lb. gauge and also experimented with four different gases, namely, air, helium, and two natural gases, one of which contained 9.4 and the other 25 percent nitrogen.

Comparing Deaton and Frost's results with those obtained by Laulhere and Briscoe using a gas substantially free from nitrogen or other inert gases, it is apparent that the gas used by Laulhere and Briscoe carries relatively more water than the gases investigated by Deaton and Frost. In order to provide a chart that would give safe values of water content tending toward the high side, the writer accordingly used the method described in Deaton and Frost's paper to extrapolate the water content

Fig. 3

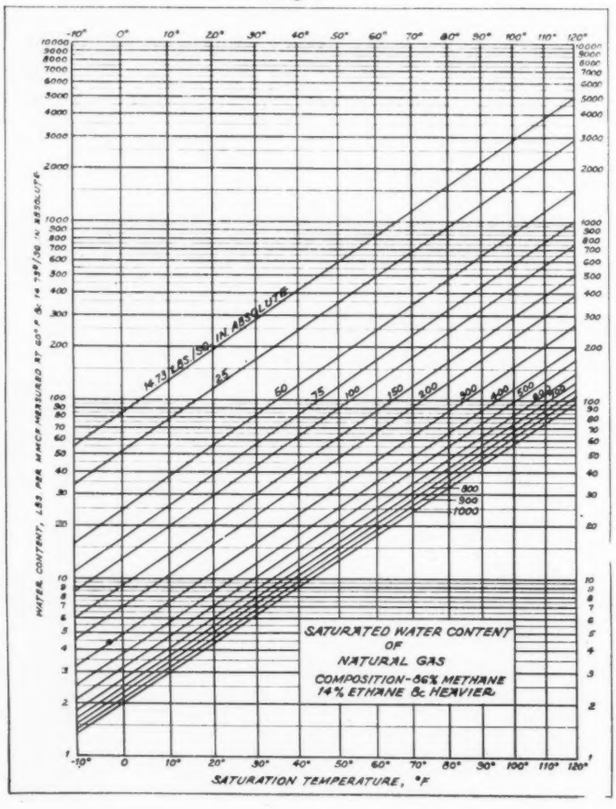
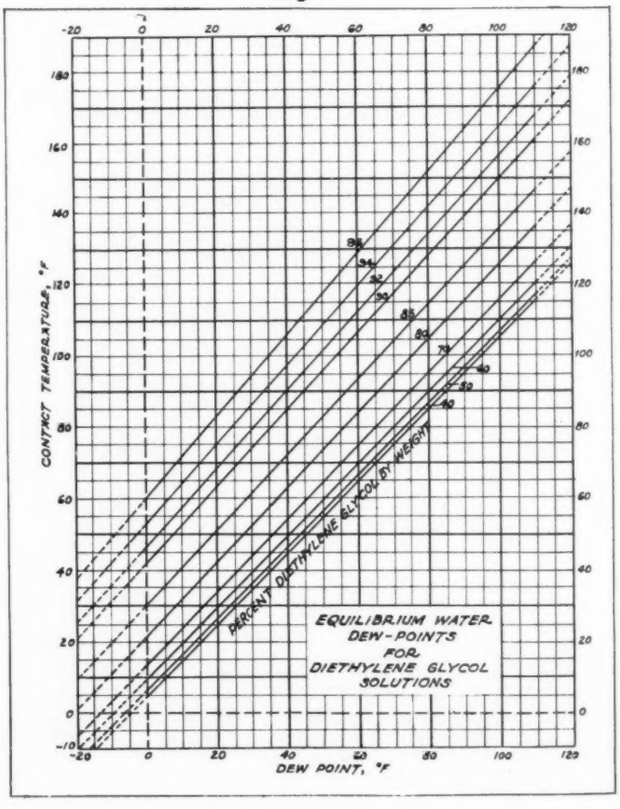

WATER CONTENT, LBS PER MMCF MEASURED AT 60° F & 14.73 LBS/SQ IN ABSOLUTE
SATURATION TEMPERATURE, °F
14.73 LBS/SQ IN ABSOLUTE
SATURATED WATER CONTENT OF NATURAL GAS
COMPOSITION-86% METHANE 14% ETHANE & HEAVIER

Fig. 4


CONTACT TEMPERATURE, °F
DEW POINT, °F
PERCENT DIETHYLENE GLYCOL BY WEIGHT
EQUILIBRIUM WATER DEW-POINTS FOR DIETHYLENE GLYCOL SOLUTIONS

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2. Be sure the rope is the proper one for the service. Ask your Hazard wire rope man.
3. If drums or sheaves are small, or the kinking tendency pronounced, specify LAY-SET Preformed, the rope that resists bending fatigue and kinking.
4. Check your sheave or drum grooves. Worn grooves play havoc with wire rope.
5. Don't let rope rub against any standing part.
6. If the rope deviates from the center plane of the sheave more than 1½ degrees, undue wear will result.
7. Keep sheaves aligned and bearings tight and properly lubricated.
8. Don't allow bad spooling on drums. Hazard LAY-SET Preformed spools evenly under most conditions.
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values determined by Laulhere and Briscoe. The extrapolation was carried up to a maximum pressure of 1000 lb. and to a temperature of minus 10° F.

It should be noted that, according to comments in the paper of Deaton and Frost, the water content curves appear to depart from straight lines on the graph of Log W versus $\frac{1}{T}$ at temperatures below 60° F. with pressures above about 300 lb. The nature of this departure is such as to increase the actual water content of the gas at these low temperatures and high pressures. In applying the chart to conditions in this range a liberal factor of safety should therefore be used until further information is available.

In plotting Fig. 3 the effects of Boyles' law deviation or "supercompressibility," as well as the effect of total pressure on the vapor pressure of the water itself are taken into account. The chart therefore shows for any given condition of temperature and pressure the true saturated or equilibrium water content of natural gas, expressed in pounds per million standard cubic feet measured at 14.73 lb. per sq. in. absolute and 60° F.

Fig. 4 shows in a revised form the dewpoint of gases in equilibrium with water solutions of diethylene glycol of various strengths under various equilibrium temperatures. This chart is used in determining the contact of equilibrium temperature required to attain a given dewpoint when using a solution of a given strength, or conversely, to determine the solution strength necessary to obtain a given dewpoint at a given contact temperature.

The equilibrium data presented in Fig. 4 are based on information obtained experimentally by the writer, and agree well with experimental and experience data that have been accumulated from a number of actual dehydration plants during the last five years. An equilibrium chart published by the Carbide and Carbon Chemicals Corporation shows in general smaller dewpoint depressions than those that have been attained in actual practice.

Fig. 5 shows boiling temperatures of diethylene glycol solutions of various strengths under various pressures. This chart may be used to estimate the still base temperature required to attain any chosen solution strength.

Fig. 6 presents an equilibrium dewpoint chart for calcium chloride solutions. The V-shaped curve in the center of the chart represents the phase boundaries within which liquid solutions are possible. The lefthand side of the V represents the temperatures at which pure water ice will form in the solution, whereas the righthand side of the V represents the temperatures at which crystals of the 6-molecule hydrates of calcium chloride begin to form.

Fig. 7 presents boiling temperature data for calcium chloride solutions under standard atmospheric conditions, for use in designing solution evaporators.

The data presented in these curves have been verified against actual operating experience over a number of years, and have been found sufficiently accurate for commercial design purposes.

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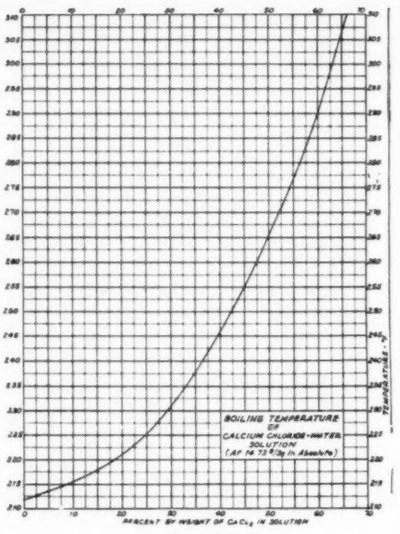


Fig. 7

Fig. 5

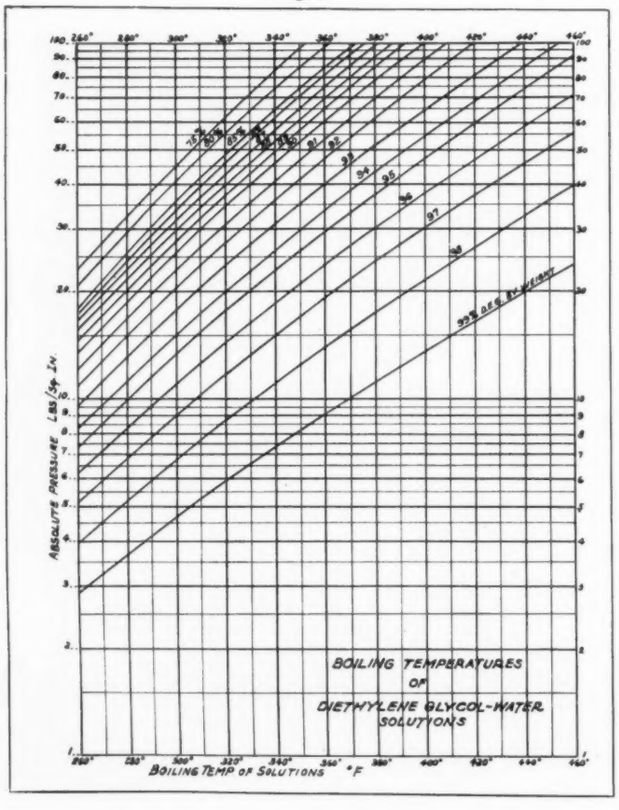
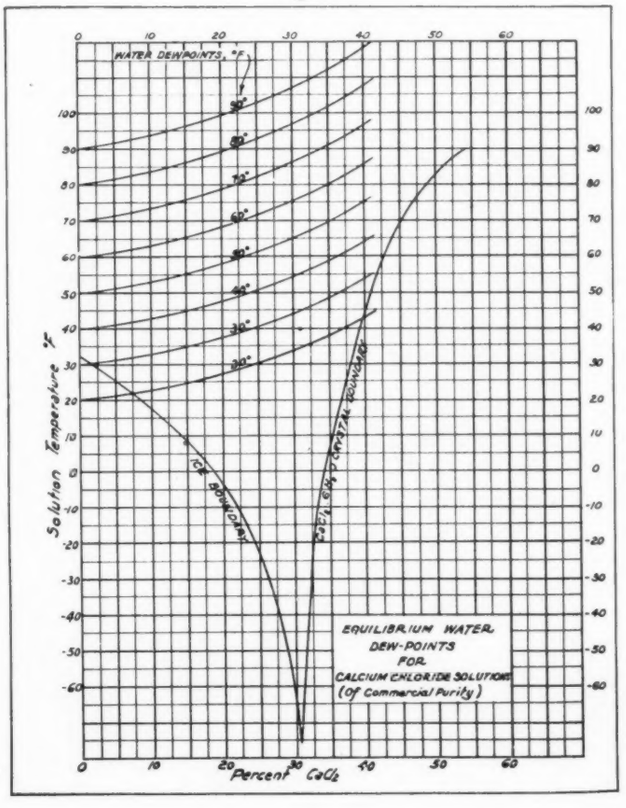


Fig. 6



This is the 1ST in a series of messages

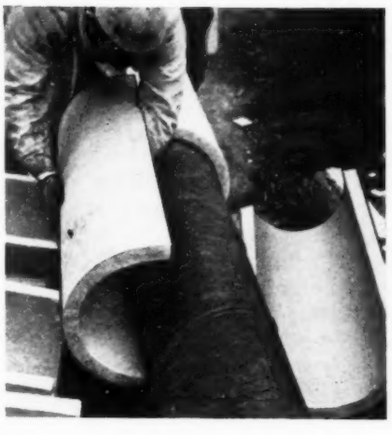
Dealing with the problems in heat insulation faced by refinery engineers and solved by using UNARCO unibestos

1a THE PROBLEM

Removing insulation for periodic inspection of hot oil lines presents a problem. It can be costly and time-consuming unless material is applied that lends itself to frequent handling. Frequent inspections lower the efficiency of ordinary insulations and very often necessitate replacement.

1b THE SOLUTION

It is suggested that a combination of Super and Standard Unibestos in single layer construction be applied. This will permit easy removal from the pipe and the insulation can then be set aside during the test. After the test Unibestos can be reapplied without any loss of efficiency. In addition, considerable time will be saved through use of Unibestos, the sectional insulation, in single layer construction.

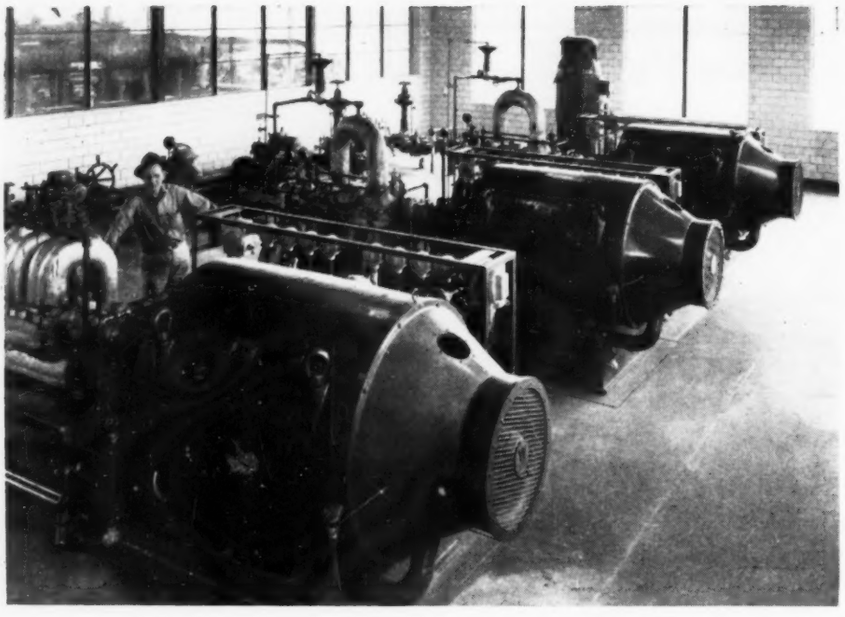


unibestos is available in Standard material, for temperatures up to 750°; Super, with a temperature limit of 1200°; Combination, with a temperature limit of 1200°. These temperature limits permit the use of one material at maximum efficiency for a wide range of purposes. Unibestos is available in half sections up to 30" pipe diameter and from 32" to 60" in quadrants from ¾" to 5" in thickness. Standard and Super Unibestos are both available in single layer construction with provision for expansion in piping, where it is required.

TWO ARMY-NAVY "E" AWARDS FOR EXCELLENCE IN WAR PRODUCTION
ONE TO THE CICERO, ILLINOIS PLANT, ONE TO THE PATERSON, N. J. PLANT

UNION ASBESTOS & RUBBER CO.

GENERAL OFFICES: 1821 SOUTH 54TH AVENUE, CICERO, ILLINOIS • NEW YORK • SAN FRANCISCO • PATERSON, N. J.



The largest explosion-resisting motors ever built drive the centrifugal pumps at this station on the Plantation Pipe Line System, which transports refined products

(Photo courtesy Westinghouse Electric & Mfg. Co.)

PETROLEUM ENGINEER Exclusive Feature

by

Wallace A. Sawdon

Pacific Coast and Foreign Editor

California-Texas Pipe Line May be Needed

☆ Demands of war point to necessity for connecting link between West Coast pipe-line systems and those east of the Rockies

ALTHOUGH the United States has a pipe-line system for the transportation of crude oil and petroleum products that is so far reaching in extent that it connects all the prominent industrial locations east of the Rocky Mountains with the source of supply, it has been unable to meet fully the wartime demands of the Nation. Peacetime economy made the utilization of considerable water-borne transportation advisable; opposition of the railroads prevented the construction of some lines that otherwise might have been built. With the breakdown of tanker service due to the lack of bottoms and to the submarine menace, and to the inability of the railroad to take care of the exigent loss of water-borne transportation facilities, the supply of oil to the east coast has been drastically curtailed.

The minimum satisfactory requirements of all the territory east of the Rocky Mountains can probably be met by the new lines being constructed and proposed. Already the 24-in. line extending 1388 miles from Longview, Texas, to Phoenixville, Pennsylvania, has been completed to Norris City, Illinois, a distance of 531 miles. From the Phoenixville Junction terminal a 20-in. line will extend to Bayway, New Jersey, and another 20-in. line to Philadelphia. Upon its completion, which is expected about June 1, 1943, deliveries of crude oil through this, the largest oil pipe line in the world, will be 300,000 bbl. per day.

The Defense Plant Corporation also authorized an 8-in. line across northern Florida, a distance of 198 miles, and another 8-in. line from Greensboro, North Carolina, to Richmond, Virginia, a distance of 175 miles.[1] Announcement of an 836-mile, 20-in. products line from Beaumont, Texas, to Seymour, Indiana, has also been made.

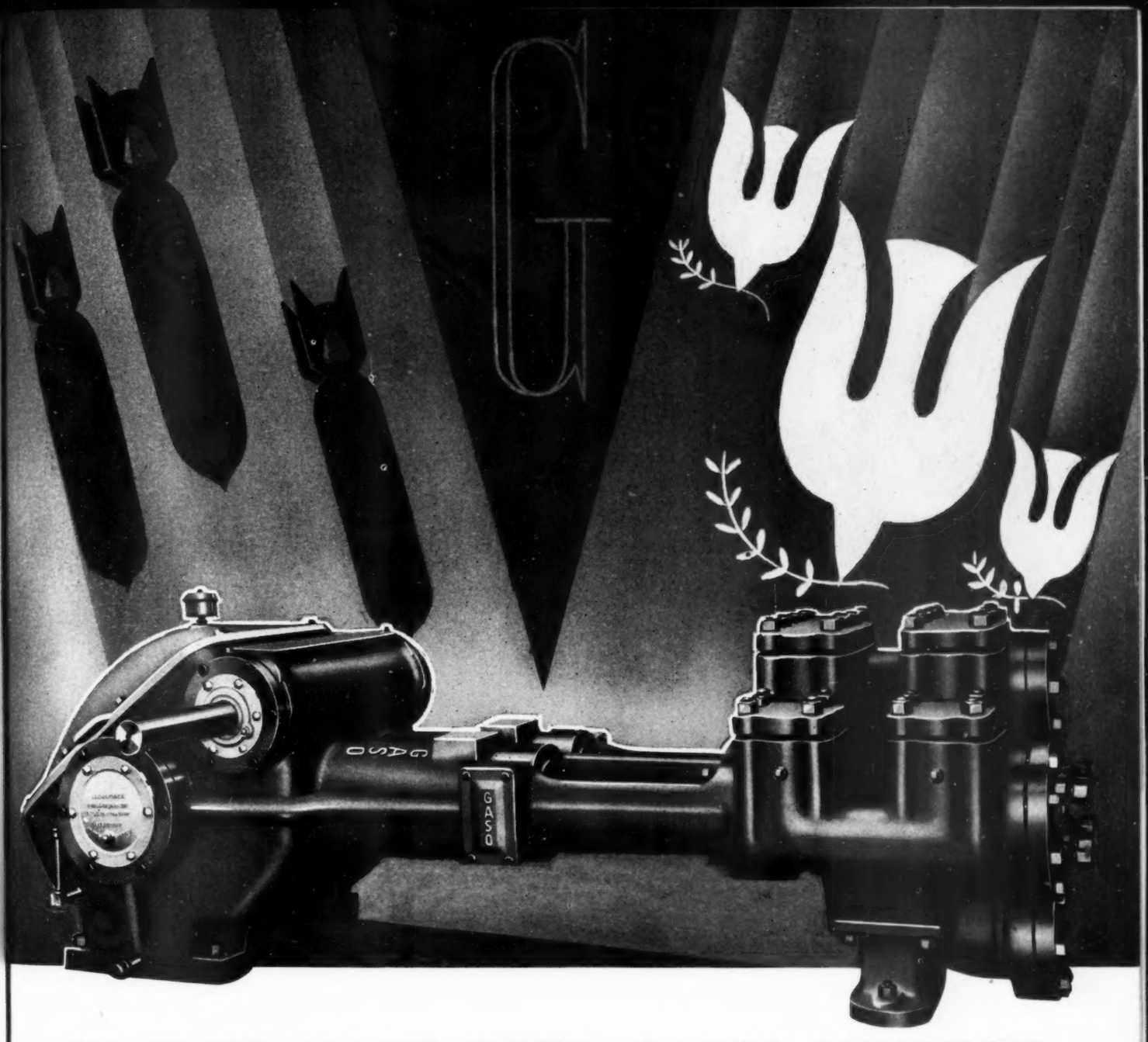
All oil pipe lines west of the Rocky Mountains are in California and extend from the San Francisco Bay area to Huntington Beach with lines connecting to ports on the Pacific from which shipments are made along the coast. Tanker shipments to northern California, Oregon, and Washington have naturally been curtailed and rail shipments to the inland western states have just as naturally been reduced; but the shortage of petroleum products in this territory has not become acute. Some gas lines within the area served by the California pipe-line system have been converted to the transportation of oil or petroleum products but no new pipeline construction of importance has been done in California during the present war period.

No Connecting Link

There is not, however, any connecting link between the extensive pipe-line system east of the Rockies with the isolated system of California. Up to the present time there has been no need for such a connecting link because the California fields have been able to meet the demand for oil on the Pacific Coast. Nevertheless, fuel oil requirements have been such that attention has been directed to the possibilities of a shortage, particularly if military operations in the Pacific become as extensive as expected.

The idea of building a pipe line from Southern California to Texas is not new. As early as 1925 W. N. Beadle of Byron Jackson Company stated in an article in the *General Electric Review* that "At the present time, there is a network of oil pipe lines, most of them fitted with steam pumping units, extending in a semi-circle from Texas and the Gulf of Mexico, northward and eastward via the Great Lakes to New York. Oil fields are

[1] A description of the 1261-mile products line of Plantation Pipe Line is given in "Electric Features of Design and Operation of the Plantation Pipe Line," by M. A. Hyde and H. B. Britton, a paper presented before the A.I.E.E., Chicago, June 26, 1942.



HOW TO MAKE YOUR GASOS STRETCH FROM WAR TO PEACE

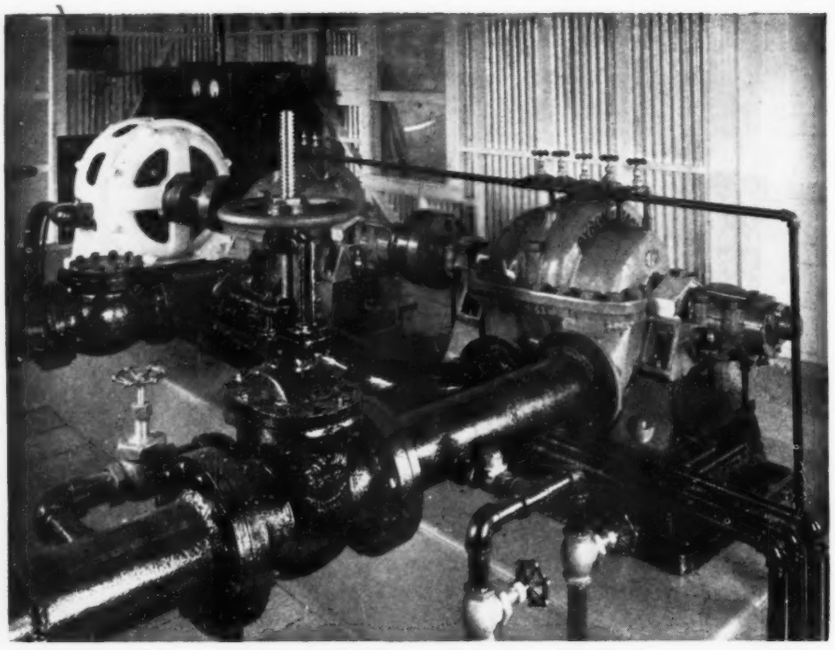
Breakdowns in pumping equipment may under present conditions result in costly delays or even inability to replace the unit that fails. That's reason aplenty for instituting a special wartime program of conservation . . . The following suggestions are designed to help you in getting out of your Gaso Pumps all of the trouble-free service that has been built into them.

1. **Keep pumps clean.**
2. **Change lubricant in crank case at least twice a year. Use an SAE 90 EP Gear Lubricant in crank case, and an SAE 30 Motor Oil for roller bearings that have separate housings.**
3. **Adjust bearings at first sign of looseness.**
4. **Do not overload pump.**

While our facilities are at war, our thoughts are still on peacetime customers; and we stand ready to do anything in our power to assist them in the job of conserving existing pumps until such a time as we are able to provide the new and even better models which will emerge from the expanded facilities and broadened experience of wartime service . . . Gaso Pump & Burner Mfg. Co., 902 E. First Street, Tulsa, Oklahoma. Export Office: 149 Broadway, New York. Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.

GASO PUMPS

FOR EVERY OIL INDUSTRY NEED



Motor, pumps, special pressure switch and starting compensator with metering devices in the first electric-centrifugal installation for boosting oil pipe-line pressure. The station is in California
(Photo courtesy Byron Jackson Company)

being developed in New Mexico and adjacent territory. California is at present the foremost oil-producing state. A pipe line from Los Angeles to tidewater Texas would complete the system, and provide for the free movement of oil (or gasoline) either eastward or westward. Thus it would be of tremendous value in meeting market conditions, accommodating new production centers in years to come, and insuring a ready continuity of supply in time of war."

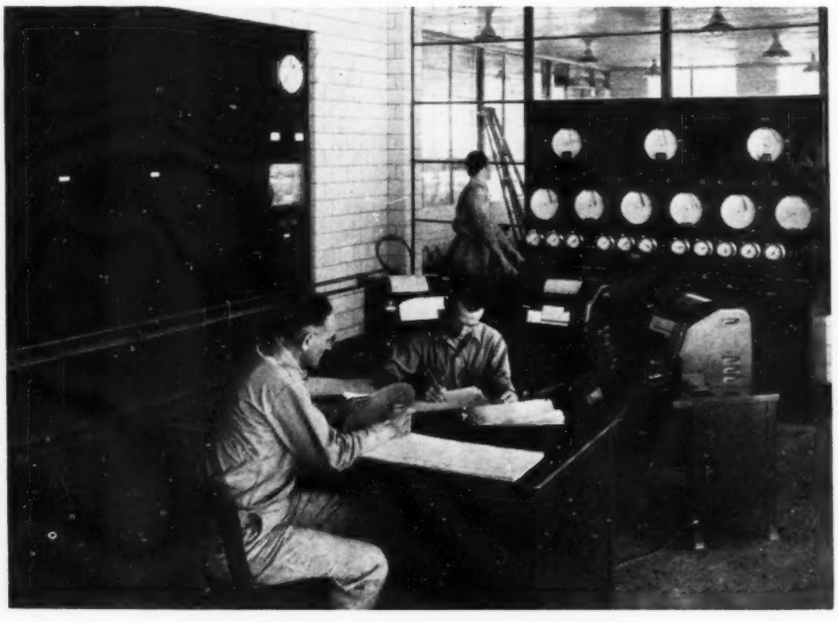
The attention of the administration has recently been directed to the advantage of such a line in averting a crisis on the Pacific Coast similar to that of the Atlantic seaboard. Adequate supplies of fuel oil must be insured on the west coast not only for operations in the Pacific theater of war but also for the expanded merchant marine that is expected to be in service on the Pacific Coast after the war. Another factor to be taken into consideration is the possible supply of oil in the northern part of Mexico lying south of the Rio Grande from Juarez eastward to the Gulf of Mexico. Although exploratory work in that area has not been extensive there are definite indications from the geological viewpoint and some geophysical work has been done. Should oil in great volume be discovered in this territory a pipe line to the west would make it available for utilization on the west coast.

The total known reserve of California at the present time is estimated at approximately 3 billion barrels. That of West Texas and New Mexico alone exceeds this amount. The known oil reserve of the United States east of the Rocky Mountains is probably 17½ billion barrels so the California reserve is not much more than 15 percent of the country's total. It is true that in normal times oil from the Gulf Coast can be transported by tanker through the Panama Canal to the Pacific Coast but an emergency caused by extensive Pacific operations that would require more oil than can be produced at a maximum efficient rate would require a readily available additional supply. There is no reason to overtax the productive capacity of California wells and reduce the ultimate yield in order to meet an emergency that could be handled by bringing in oil from another area that has the supply readily available.

Although a pipe line from El Paso to Los Angeles is here considered as a war measure it must be remembered that the Pacific Coast is in its infancy as an industrial area and is still young in trans-Pacific commerce. After the war, Eastern Asia, Australia, and the Western Pacific area in general are going to be more highly developed than ever before. Demands for petroleum products in the Pacific Coast states will probably continue to increase but what further reserves will be discovered in California to meet later demands cannot now be foretold, as exploratory work will probably be accelerated after the war. Should future peace-time needs make additional oil necessary, the laying of a pipe line to carry oil from other sources will not then be of such urgency and materials for its construction will not be so hard to obtain.

Design of Stations

Considering the construction of a pipe line from Los Angeles to El Paso as an immediate war measure, the booster stations would have to be designed with due consideration taken of shortage of materials and of maximum insurance against interruption of service. When such a pipe line was suggested in 1925 the first pipe line of any size equipped with electric-centrifugal pump units had been completed in California only two years before. This pioneer line also



Control room in a station on the Plantation Pipe Line. Here are teletypes in center, switchboard at left, and control board in right background
(Photo courtesy Westinghouse Electric & Mfg. Co.)

GUARD THOSE VALVES OF YOURS

New valves will be *harder* to get—even if you work directly for the war effort.

There are not sufficient materials for valves—or wear resisting parts. Allocation will reduce, still further, amounts valve manufacturers have been able to obtain for lower ratings. And control is directing the uses to which all valves are shipped.

Too few of us have the feel of this war—yet. But, it is our belief that those who need continued operation of valves will be well advised to adopt conservation and substitution right now—as part of the price loyal citizens pay for a victorious war. It is no whit smarter to try to find "angles" by which materials needed for active war can be diverted to our plants than it is for a commander in the field to withhold an order to fire—to save his own hide.

READING-PRATT & CADY

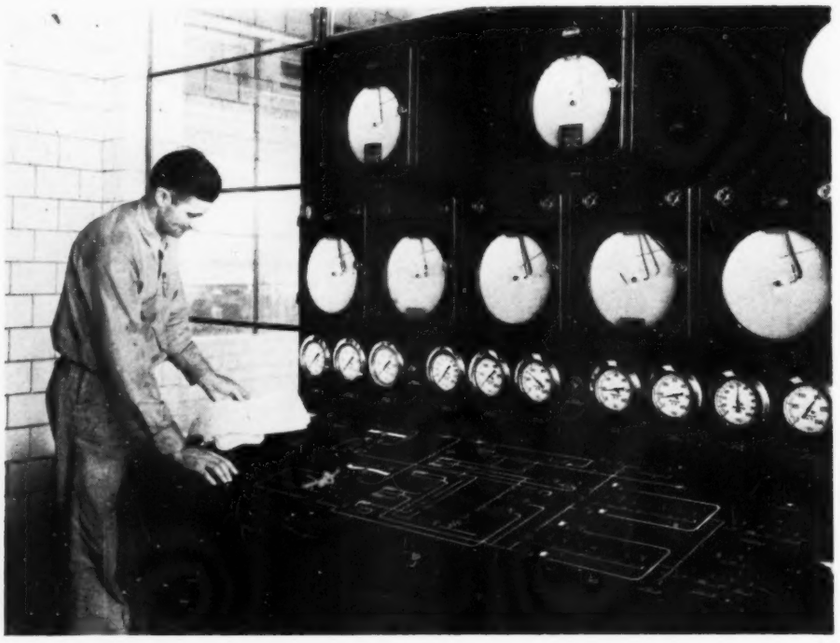
MANUFACTURERS OF

R CAST STEEL VALVES P&C CO BRASS AND IRON VALVES

D'ESTE ENGINEERING SPECIALTIES

Reading, Pa., Atlanta, Boston, Chicago, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, San Francisco

A DIVISION OF **AMERICAN CHAIN & CABLE COMPANY, INC.,** BRIDGEPORT, CONNECTICUT



Control board at a Plantation Pipe Line station showing in detail the schematic piping layout of the station and the attendant instruments
(Photo courtesy Westinghouse Electric & Mfg. Co.)

included the first electric-automatic booster station, which was equipped with a pressure regulator that automatically started and stopped the pump by changes in line pressure. Since that time electric-driven centrifugal pumps have been widely employed for pipe-line duty, the largest line in the world now in the process of construction being equipped with electric-centrifugal pumping stations.

The electric-centrifugal pipe-line station has been found economically sound and has made feasible the great defense trunk pipe lines recently constructed and now being laid. Electric power supplied by interconnected networks are generally available for low cost and reliable service. Of particular importance under war conditions is the reduction of housing space by the use of centrifugal pumps and the elimination of surge or storage tanks at booster stations. Not only is material saved by these factors but the above-surface equipment is reduced to a minimum. The closed system is one of the greatest advancements in pipe-line operation and it provides for the utilization of pressure remaining in the stream as a suction pressure. Cavitation "may be overlooked for the newer pipe-line systems, because they are designed to give ample positive suction head to avoid cavitation even at the starting station, while for successive stations pressure regulators on the suctions provide sufficient inlet pressure. On the first station, or in those with tank farms, if the static head provided is insufficient, auxiliary pumps supply the required suction pressure. Furthermore, the pumps being multistage, only the first stage would have to be changed to reduce cavitation tendencies so that the total effect would be rather small."[2]

Safety Factors

If considerations of safety have to be extended it might become desirable to transport petroleum products instead of crude oil through a line from Texas to Southern California. With the transportation of lower viscosity liquids, safety features could be further extended by the use of the submerged stuffingboxless type of pump. Such an installation would take no manpower, as no attendants would be needed at the stations; with the stuffingboxless unit as a pipe-line pump for an automatic station the need for constant attendance would be removed. Stuffingbox troubles with attendant loss of valuable liquid would be eliminated; also, fire and explosion hazards would be reduced to a minimum. Sabotage and surface bombing of this type of station would be least readily accomplished.

With the present development of this kind of pump more stations would probably be necessary, but the additional stations would be justified both from the savings in cost per station and the added insurance against interruption of operation.

Should conditions develop to make it desirable to provide underground storage, many economical sites could be selected along a pipe line from Texas to Southern California. Such reservoirs could probably best be situated in the side of a hill or mountain to provide sufficient overburden to protect the stored oil from bombing. Although it is extremely unlikely that such a danger will arise, the contingency can readily be met if a line between California and Texas is ever built.

Such a line would provide low transportation costs to intermediate points after the war is over, and the flow of liquid could be from either east to west or west to east. In fact, one end of the line could be used for one direction of flow and the other end for the opposite direction.

From the latest reports it appears that plans are being formulated for the construction of a 10-in. or 12-in. line from El Paso to Los Angeles. How far these plans have been developed or what the chances are for actually building the line has not been disclosed.

[2]From "Some Problems in the Selection and Operation of Centrifugal Pumps for Oil and Gasoline Pipe Lines" by A. Hollander, *Transactions of A.S.M.E.*, August, 1942.

The California Petroleum Company, which installed the world's first automatic electric-centrifugal pump station, was taken over by The Texas Company, which is still operating the station

P 422.333.

Automatic Control of Feed Water to Boiler

PETROLEUM ENGINEER Exclusive Feature

PART 2 (Concluded)

by J. A. Campbell
Research and Development Engineer

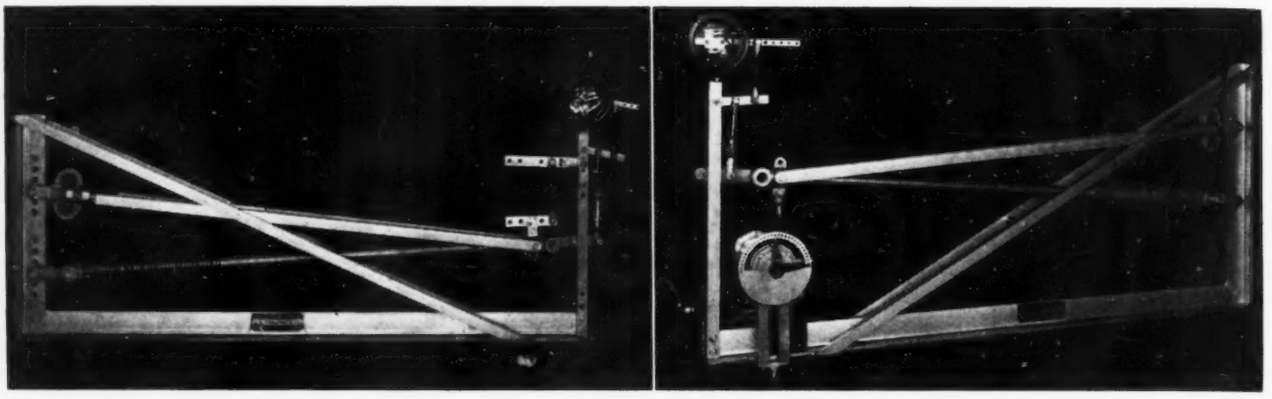
IN our work we have come across dozens of boilers equipped with feedwater controllers that have been bypassed for years, the feeding being done by hand. This has been due largely to a lack of understanding of the simple fundamentals of control. The control first must be set so that the water level will cut across the inclined tube near the center of its working range. This point should be about two-thirds the way up the tube. The most important function of the tube is to prevent low water, so the reserve for opening the valve should be about twice what it is for closing. Many controls have been installed on boilers at such a level that the water was too near one end of the tube or even did not cross the tube at all. If a controller is set too high, the tube is filled mostly with steam and is expanded to almost its maximum at proper level, so has no reserve for opening the valve should the level drop. If the controller is set too low the reverse is true and the tube is so nearly contracted that there is no reserve for closing the valve if the level should rise due to a lightened load. With the tube properly set, a wide range of movement is available for valve operation in either direction. A very simple method of determining just where the water cuts across the tube is by "spitting" the tube in a manner similar to that employed by a housewife in testing the heat of a flatiron. If so tested, the steam lead and that portion of the tube above the water level will "ping" to the moistened finger. Below the water level the "sizzle" is much slower and just above the fins the saliva will exaporate quite slowly. Most manufacturers send out with their controllers detailed instructions on how to locate them with reference to the water level. We have found, however, that there is a decided difference between the level in the boiler and the point where it cuts across the tube in many installations and so have provided extra holes in the frame to permit the tube to be very simply raised or lowered 1 in. without disturbing the piping. The rack may be moved an inch either way on the rod, which is sufficiently long for this purpose. This difference in levels can be readily explained. Water has a very high coefficient of expansion and, as the connection from the water column to the boiler is usually from 12 to 20 in. below the level in the gauge glass, the whole set-up gives, in effect, a U-tube with an extra leg on one side. One leg is in the boiler and assume the water in this leg is at a temperature of 360°F. One of the other legs is in the water column, which, if out to one side of the boiler, will be 100 to 150°F. cooler than the water in the boiler. Let us digress at this point to state that practically every fireman knows that when he blows his column the water will equalize back to a point from ¾ to 1½ in. higher than before he disturbed it. This is because the water in the column being isolated from the boiler, cools by radiation and contracts, becoming more dense, consequently a shorter column of this cooler water will balance a higher column of the hotter water in the boiler. The water column, however, even after being blown down and containing water at approximately the same temperature as the boiler, will not show the true level in the boiler. It is always lower, how much lower will depend upon the distance from the water level in the glass to the point where the column connects with the boiler. Assume this point to be 20 in.; the water in the boiler is full of steam bubbles that lighten it about 6 percent for average firing, and 6 percent of 20 in. is 1.2 in. After the water column has cooled down, a drop of about 1 in. occurs due to difference in temperature and the true level is 2.2 in. higher in the boiler than shows in the gauge glass. This, however, is on the safe side and explains why fire-box boilers with a short gauge glass tapped directly into the head, give drier steam than a horizontal return tubular boiler with the outside column connected much lower down. It also explains why the former blow up much more often than the latter.

Getting back to our three-legged U-tube, the third leg is the piping connecting the boiler to the back end of the tube and the tube itself. The temperature in this leg will be still much cooler than the water column. How much cooler will depend on a number of factors: whether or not the boiler is insulated, whether or not it is housed, length of this piping, and size of this piping. On an average this difference in temperature will make a difference of about 1 in. in the levels when the return is 20 in. down but, as all these factors vary, a ready adjustment is provided for raising and lowering the tube so that it may be so placed that the water will cut across it at the proper point.

There seems to be no standard at all among boiler manufacturers for the distance between the water level and the point of entry to the shell of the lower water column connection, yet this determines the degree of falseness of the level and has a decided bearing on the quality of the steam. In one instance, the writer found fire-box boilers equipped with a water column whose bottom return was connected to the shell within 2 in. of the mudring. Upon inquiring whether the boilers were putting out wet steam it was learned that there had been trouble with wet steam for 18 years. The question was then asked how long the boilers had been installed and the answer was 18 years. After the principles involved were explained the connections were raised to a reasonable height, resulting in the driest steam the boiler had raised in 18 years. The writer shudders to think of the waste of fuel, not to mention the many other losses incurred by this condition in that 18-year period in this one plant. The level they had been carrying in the boiler was just 5 in. higher than that which showed in the gauge glass.

Installing the Leads

Another important factor in the installation of any controller is the manner of installing the leads connecting it with the boiler. The purpose of these leads is to equalize the pressure between the boiler and the tube so that the water in the tube will follow the fluctuations of the level in the boiler. Never under any circumstances should a globe valve be used on either the steam or the water lead because a globe valve is so designed that it contains a trap. Only gate valves or cocks should be used. A high point in the steam line will cause no difficulty provided there is no low point on either side where condensate might trap and shut-off the steam from the tube. Condensate should be able to drain freely from any high point down to the controller on one side or back to the water column on the other. The reverse is true



Left—Boiler feed-water controller equipped with micro-switch for starting and stopping the electric pump and Mercoid snap-action switch for fuel cut-off. Right—Controller of 2-in. rotary type with high-low Mercoid electric alarm signal switches

of the water lead. It may run from the column down to the floor and up to the regulator so long as it has no intermediate high spot for the entrainment of air freed from the water. A small air pocket in this line will seriously interfere with the operation of the tube. The writer has seen a pocket of only ¼ in. throw the level in the tube off as much as 6 in. Air and gas traps in lines is a subject that all hydraulic and pneumatic engineers leave alone because the best way to figure them out is not to figure them in.

Never Paint Tubes

Another very important point is that the tubes should never be painted. Painting red brass is like gilding a lily. When you tell the painters to paint the boiler plant, give strict instructions that they must not paint the thermostatic tubes, then send someone out immediately to clean the paint off. There is something about these tubes that is irresistible to the painter. Paint will surprisingly lessen their ability to radiate heat and will render them very sluggish. It is good practice occasionally to take a strip of emery cloth and brighten up the tube. A bright surface is much more effective in radiating heat than a dull surface.

Pump Governor Essential

Operators sometimes try to operate a battery of boilers each equipped with a regulator but with no pump governor on the pump. This is a very risky procedure. A control valve is the same as an adjustable orifice fixed for a certain flow condition. The amount of flow depends upon the pressure drop across the orifice. If the pressure drop is 40 lb. a much greater flow will result than were the pressure drop 25 lb. So by speeding-up a pump and raising the discharge pressure the level in the boiler can be raised even though the control valve is kept at the same opening. A pump governor will maintain a steady differential against the control valves and if several of these open the lessening of resistance at this point will drop the discharge pressure, causing the pump governor immediately to open and speed-up the pump to a point where the discharge pressure is back to normal, insuring plenty of water to those boilers requiring it. As the level builds back to normal, the valves pinch down, the discharge pressure builds up, and the pump slows down. In operating without a pump governor it is necessary to have the pump bucking throttled valves most of the time. This is very wasteful of steam and likely to "blow" a gasket. If there is only one boiler to equip, steam instead of water may be put through the control valve so the controller regulates the speed of the pump to maintain a constant level. When a constant level is spoken of the term is a misnomer because the level must change some in order to be controlled. A sensitive controller will maintain a level within ¼ in. under most conditions.

Changing Controller Adjustment

Some operators seem to have difficulty in understanding just what happens when the adjustment is changed on a controller to raise or lower the level in the gauge glass. Assume that a boiler is firing under a uniform load and the water level stands 2 in. in the glass. With a constant differential pressure this means that the valve is open a definite amount, say, 1/64 in. Now change the adjustment on the valve to raise the level in the boiler. Obviously, if the valve is opened wider than it has been running, water will enter the boiler faster than it will evaporate and the level will begin to rise; but as it rises in the boiler it also rises farther (because lengthwise) in the tube, chilling the tube and so producing contraction and a pinching of the valve. As soon as the valve has pinched down to the same opening (1/64 in.) that it had before, the level will stop rising and carry at this higher elevation. It will work in the opposite manner if we wish to lower the water level because pinching down on the valve will put less water into the boiler than is being evaporated until the level has dropped sufficiently to open the valve to the same degree as it is normally opened, then the level will become steady at this point. The point to bear in mind is that the valve has a fixed opening for a fixed rate of steaming and when this opening is changed without changing the rate of steaming, the change is only temporary and the valve will come back to the same opening due to the correction made upon it by the expansion or contraction of the tube.

Indicator Advises of Scaling-up

One distinct advantage of a valve-opening indicator is its ability to advise the operator of "scaled-up" piping. The feed-water piping tends to scale-up at the point of entry to the boiler. Often the writer has seen scale build up at this point to such an extent that the aperture for passage of the water was no larger than a lead pencil. The cause of this is quite simple. The boiler shell stores a tremendous amount of heat. This heat flows by conductivity back along the feed-water line entering the boiler. Its potency is soon lost, however, because of the much cooler water flowing in the opposite direction. The effect is a deposit of scale in the last section of piping that is thickest at the very inlet and tapers down as it goes away from the boiler. When this scale builds up to a point where it begins to restrict the flow, the operator usually thinks his controller valve is not sufficiently open and makes an adjustment. This removes some restriction at the valve and brings a higher pressure to bear on the orifice formed by the scale, forcing more water

through and raising the level. This might happen on the day shift and a few nights later, due to more scale accumulation, the night operator might open some more on the control valve. Still later, the evening operator might make a further adjustment. Soon the controller is so widely open that it is not controlling at all and the operator might not be able to maintain the water level and have to cut the boiler off the line. With the indicator, each adjustment can be observed and as soon as an operator notices that one of his regulators is running two or three points wider open than the others, or than it was running originally, he knows that the "squeeze point" has shifted from the control valve to a restricted opening and so has the boiler shut down and the piping cleaned out.

It is sound practice to equip boilers with signal devices sounding alarms on a low-water condition. Some operators like an alarm for high water as well. There are a great many things that can happen to cause low water. The water supply might fail causing the pump to lose suction. A rocker-arm key might come out, improperly selected packing might swell and stop the pump, a piston nut might come off, the piping might scale-up, or the controller might not function. Any boiler that is not under the "wakeful" eye of an attendant should be equipped with some type of alarm. The cantilever principle adapts itself well to all types of signalling. There is about ¾ in. movement of the outer end casting and this is ample for the tilting of Mercoid switches, the throwing of micro-switches, the blowing of steam whistles, and the tripping of snap actions for operating cut-off valves on the fuel. Lights, bells, howlers, and klaxons may be used as alarms and solenoids for operating valves as cut-offs where electricity is the energizing force. Manual resets are desirable because if the fuel should cut off for a short period and then come on again, a disastrous fire-box explosion might result. Most fuel cut-offs are snap-action manually reset.

An interesting problem put to the writer by Army engineers resulted in the development, for use in isolated camps where the electric current was not too reliable, of a snap-action admitting steam to the diaphragm of a valve in the fuel line. When sprung by an abnormal expansion of the tube caused by low water, the action opens a ¼-in. valve, admitting steam pressure to the diaphragm of a valve in the fuel line and at the same time closing a vent so the pressure will close the fuel valve. When cocked by manual re-set the steam is shut-off and the vent opened in the one operation. This releases the pressure on the diaphragm and the spring loading beneath opens the fuel valve so the fire may be re-lighted. For civilian use, there was also added a whistle to wake the fireman to let him know his fire is out.

☆ ☆ ☆

P 094.13

Brazed Ends Make Wire Rope Safer to Handle

by F. L. Spangler, Mechanical Engineer

WHEN clip fastenings or other means of attachment are used that expose the end of a wire rope, there is constant danger that those handling the rope may receive lacerations or puncture wounds from the sharp wires at the rope end. This form of injury is said by some medical authorities to be especially dangerous, as it is likely to be deep-seated, and the injured man may consider the wound as too superficial to require immediate attention. It is not uncommon for blood poisoning to develop from such wounds when immediate treatment is not given.

A simple method of eliminating the hazard of sharp exposed rope ends is to braze the end of the rope with a bronze welding rod, running the bronze back for a distance of an inch or two from the end. When properly done, the bronze covers all the wire ends, and it also has the advantage of holding the rope end intact so that seizings can be removed.

Ends of preformed ropes can be brazed without applying a seizing beforehand, as preforming removes all unbalanced stresses in the rope wires and strands so all wires hold their position in the rope without the need for using seizings. Even so, a single seizing will insure that the rope construction will not be flattened during the cutting operation. If the rope is not preformed, it is recommended that two or three seizings be applied—one close to the end of the rope and the others a short distance (4 to 6 in.) apart.

When end brazing is done, either the same torch or a cutting torch may be used to sever the rope before bronze is applied to the end.

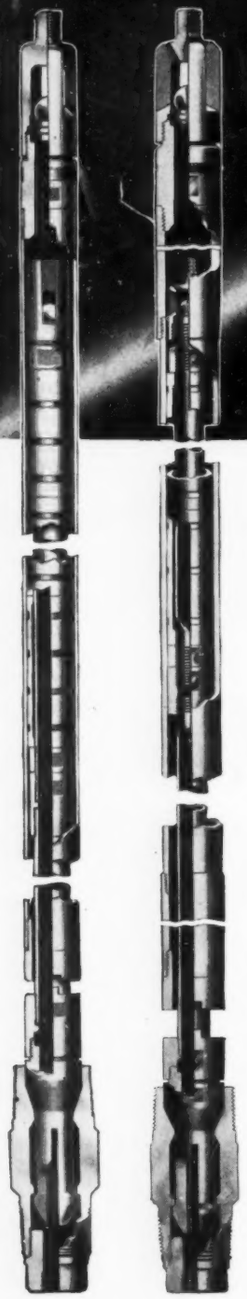
☆ ☆ ☆

Covering the sharp wires at the rope end by applying bronze with a welding torch

With the end bronze-welded the wire rope can be handled without lacerating the hands

New Manufacturing Method holds pump barrels to 1/1,000" tolerance

Flupaco has gone to great lengths to manufacture pump barrels of close tolerances. An exclusive heat-treating process eliminates distortions and misalignments. Specially designed straightening machines produce precision-aligned barrels that won't bind the plunger, even in crooked holes. And hand straightening provides the final touch of perfection.



FLUPACO "Groove Seal" Volume Producer

FLUPACO Improved Insert Pump

Intensive metallurgical research and never before attempted techniques of manufacture have produced one-piece hardened and honed Flupaco pump barrels which are even straighter than untreated barrels.

By designing special furnaces to handle long tubing lengths . . . developing automatic controls that provide better methods of quenching, straightening, honing and finishing . . . and carburizing with liquid heat, Flupaco has been able to eliminate the uncontrollable distortions and fixed misalignments common to many methods of heat-treating tubes.

This exclusive carburizing method eliminates subjecting any single part of the tube to differences in heat . . . completely controls depth of hardness on both inner and outer surfaces . . . removes danger of hardening through the tube wall, thereby preventing the brittleness common to cast liner assemblies . . . insures uniform hardening of tubes from top to bottom, inside and out, to any controlled depth.

Since the super-hard, one-piece barrels used in Flupaco "Improved Insert" and "Groove Seal" Pumps outwear many other pumps two to five times, it would seem only logical that such fine equipment would command premium prices. But Flupaco Pumps equipped with these barrels are available at prices corresponding to common multiple cast liner barrel types. Investigate today!

The unprecedented hardness measurements of Flupaco hardened and honed barrels (shown in the accompanying chart) account for the outstanding performance records of Flupaco Pumps.

	BRINELL	ROCKWELL
FLUPACO HARDENED AND HONED PUMPS	627	64 to 70-C
UNTREATED STEEL PUMPS	150 to 170	6 to 14-C

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Proper Care of Compressed Air Plants[1]

☆ Consistent maintenance of equipment essential to best operation

THE equipment required to make up a complete compressed air system, namely, compressors, compressed air lines, intercoolers, after-coolers, and receivers, must have constant care if they are to perform efficiently with a minimum of maintenance and service interruption. Small plants, as well as large plants, need persistent attention for best operation.

In the operation of compressed air equipment, it is important that the original installation be correctly made, compressors and pipe lines properly placed with respect to each other, lubrication carefully carried out, the entire unit kept clean, protected from dust and dirt, and systematically inspected and maintained. In this article the operation of air compressors will be considered first.

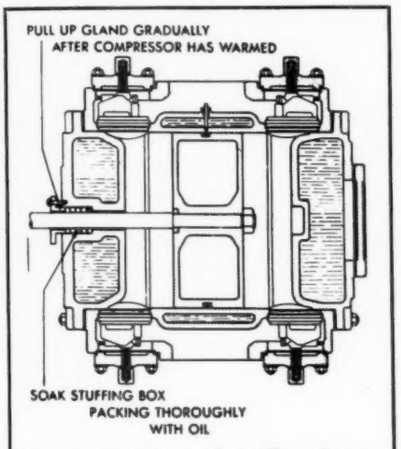


Fig. 1. Packing of stuffing boxes should be carefully done, with the packing thoroughly soaked with oil. The gland should be pulled up gradually after the compressor has warmed up, and tightened just sufficiently to prevent blowby along the rod

In starting a new reciprocating compressor or an old one that has not been in operation for sometime, it is necessary to see that the crankcase is carefully cleaned of all grit and other foreign matter and filled to the proper level with suitable oil. The cylinder lubricators should likewise be flushed and filled with the oil recommended for cylinder lubrication.

The operator should be cautioned never to use kerosine, gasoline, or other light petroleum products in flushing out cylinders or compressor frames. They are volatile and dangerous to use. It is better to waste a little lube oil in the process. Care should also be taken not to use waste or rags that leave a lint deposit, as this may clog oil passages, etc.

When mechanical lubricators are filled, it is good practice to break the oil line joints nearest the cylinder and crank the lubricators by hand until oil appears at the various joints. When this has been done, the operator can reconnect the piping with assurance that the cylinders will be provided with oil immediately upon starting.

Packing of the stuffing boxes should be carefully done. The packing used should be thoroughly coated with oil. If soft packing is to be employed, it should be soaked in oil over night so as to impregnate it as thoroughly as possible. The packing should not be pulled too tightly at the start, for this is likely to score the piston rods; rather the gland may be pulled up gradually after the compressor has warmed up and tightened just sufficiently to prevent blowby along the rod. (See Fig. 1.)

Before starting, make absolutely certain that the intake line has been thoroughly blown out and cleaned of all dirt, welding shot, scale, and other foreign matter. Many new compressors have had their valves and cylinder walls badly damaged by sucking in such foreign matter.

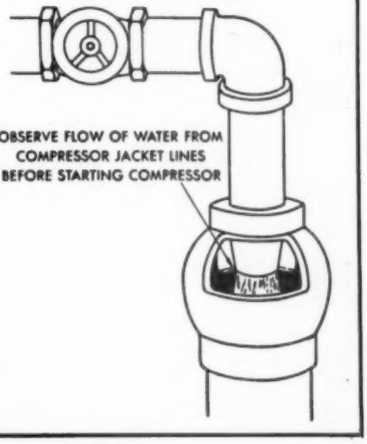
The cooling water should then be turned on to make sure there are no leaks in the water lines or in the cylinder jackets and that there is no stoppage of water flow. Jacket lines should be so connected that the flow of water may be observed either into an open funnel on the discharge or by means of sight pressure glasses, if a closed system is used. (See Fig. 2.) The circulating water lines from both cylinders and coolers should have drain valves at the lowest point to permit the entire system being drained in cold weather if the equipment is shut down.

To make sure that all parts are clear before starting the compressor, the operator should turn the equipment over several times by hand. To start the compressor, the power should be turned on gradually. It is well during the first few hours to start and stop the machine intermittently, feeling the various bearings for excessive temperature. It is common practice to run in a new machine with the compressor valves removed in order that the equipment may be broken in gradually under no load. Make certain when starting up that all working parts requiring lubrication are getting sufficient oil and that no part is heating up. After several hours' operation in this manner, the valves may be replaced, making certain that the jam screws that hold the valves on their seats are screwed down firmly. The machine may then be started with all the valves installed, being careful to build up the pressure slowly over a period of several hours.

If the source of power is steam, the drains on the steam cylinder and the steam pipe above the throttle must be opened before the compressor is started, to eliminate any condensation. The throttle valve should be opened a very small amount before starting to permit a small amount of steam to pass into the steam cylinders to heat them gradually. After these cylinders are heated, the throttle valve may be opened sufficiently to permit the compressor to turn over slowly. If the compressor is of the single crank type, it will be necessary before starting to barr it over beyond dead center.

In the operation of air compressors, it is excellent practice to establish an engine room log requiring the recording of operating data at definite periods throughout the day; also the log should record what routine daily inspections must be made, as well as what weekly and what monthly inspections should be established. As an example, instead of running the compressor without shut-

Fig. 2. It is important that the flow of water through jacket lines be observed. An open funnel as shown here or sight pressure glasses are recommended



[1]Courtesy The Compressed Air Institute.

down until there is evidence of a broken part, the valves should be removed and carefully examined every six months (every two months if the equipment is in 24-hour per day use). The log should also require an examination of the cylinder walls, to make certain the cylinder is properly glazed and adequate lubrication is provided. The interior of compressor cylinders may be examined by the aid of a flashlight by removing a valve.

If the equipment is operating properly, the valves should have an oil surface and be comparatively free from carbon. When reassembling, the operator should be careful to keep each valve assembly together and not interchange parts. If any head gaskets are replaced, extra care should be taken to insure water ports being cut in the gaskets, which must correspond in size and location to the ports in the cylinders and the heads. Failure to do this would cause overheating and possible serious damage.

At predetermined periods, the entire compressor should be carefully inspected for the presence of worn parts, new packings where needed, changing of oil in the crankcase, and inspection for complete overhaul of the equipment if it has had considerable usage. If the inspection system provides for definite routine inspection for every purpose, the equipment will be very much better maintained and cared for, with less interruption to service and lower cost of compressed air.

It is essential to examine the water jackets at frequent intervals and thoroughly clean them. (See Fig. 3.) Their condition is the best evidence of the quality of the cooling water that is used. The presence of heavy, hard scale in the jackets forms an insulation that decreases the efficiency of the water jackets. The jackets can be cleaned either by a pressure jet of water for any silt or other soft deposits, or by dilute acid if the scale is hard. The acid, 10 percent hydrochloric (muriatic), may be forced through the jackets by a small circulating pump, or by running it from a container placed above the cylinders. It is important to neutralize the acid effect in the jackets with alkali after the acid treatment to avoid damaging the metal of the walls.

In the operation of two-stage compressors, a disturbance of the normal intercooler pressure is one of the first indications of trouble. If the intercooler pressure rises, there may be something wrong in the high-pressure cylinder, such as leaky or broken intake valves or a defective piston ring. If the intercooler pressure falls below normal, trouble may be looked for in the low-pressure cylinder. Such a defect may also be observed by overheating of either

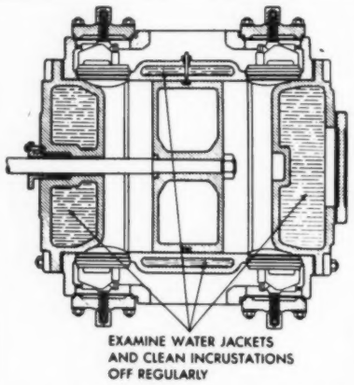


Fig. 3. Water jackets of compressors must be examined at frequent intervals and should be thoroughly cleaned regularly

discharge or suction valves. If the valve covers are unusually hot, there is evidence of leakage, which may be either in the valve or a blown out gasket between the valve and the cylinder. If there is a metallic knock in the compressor cylinder during each revolution, there is evidence of something being loose. The valve jam screw may not be holding the valve firmly against the cylinder, the pressure causing the valve seat to clatter against the cylinder; or the piston may be loose on the rod. These are warnings that should be promptly investigated to head off any serious damage about to occur. For instance, if the jam screw is not down tight, allowing the valve to pound up and down every revolution, the valve seat may break, causing a broken part to fall into the cylinder. The machine may be very seriously damaged by such a broken part falling into the path of the piston. Most cases of broken valve seats are caused by the valve being loose, whereas such a condition always gives ample warning.

Lubrication of Compressors

Under the heavy load of war-time demands, when air and gas compressors run 24 hours a day, seven days a week, lubrication must be carefully maintained.

Improper lubrication may cause serious failure of air supply. When lubrication is improperly done, and damage to cylinder walls and bearings results, a major shut-down for repair becomes necessary.

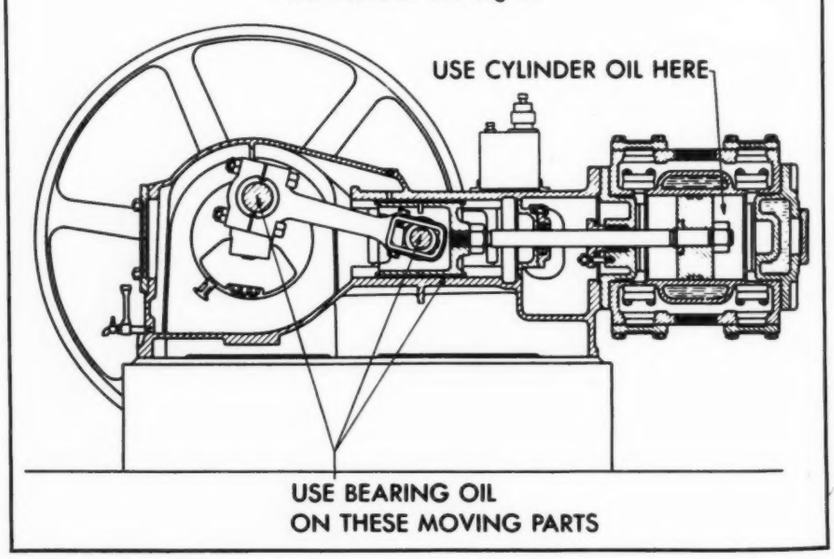
Lubrication involves the selection of the proper oil for the part to be lubricated, proper application, and in the correct amount.

The first rule to be followed in the proper lubrication of compressors or any other machinery is the use of oil according to any special specifications that may be prescribed by the compressor manufacturer, and then deal with a reputable oil company that is willing to guarantee a lubricant of maintained specification that is satisfactory for the service for which it is intended.

As many as three different types of oil may be required by a reciprocating compressor—one type for the compressor cylinder, another for the bearings of the driving gear, and a third for the power cylinders—provided the source of power is steam, oil engine, or gas engine.

Oil intended for compressors of the single-acting trunk piston type must be suitable both for the compressor cylinders and the running gear, and must be of the type known as compressor cylinder oil with specifications suitable for the particular machine. Double-act-

Fig. 4. Compressor cylinders require cylinder oil and the running gear crankcase or bearing oil



ing piston type compressors, in which the frame running parts and the compressor cylinders are completely separated, require cylinder oil for the compressor cylinders and crankcase or bearing oil for the running gear (See Fig. 4).

Compressors vary so widely as to type and use as to make it impossible to prescribe an oil specification that would be completely suitable for every condition. Specifications for compressor cylinder oils, taken from the *Trade Standards* of the Compressed Air Institute, which would apply generally to most air compressor installations are as follows:

Flash point, 350° F., minimum.

Viscosity S.S.U. at 100° F., 245 minimum.

Viscosity S.S.U. at 210° F., 45 minimum.

Pour point, plus 35° F., maximum.

Neutralization number, 0.10 maximum.

Conradson Carbon residue, 2.0 percent maximum.

As stated, special requirements call for special treatment. If a gas compressor, special consideration must be given the question of cylinder lubrication. Various gases have a high affinity for oil, leaving the cylinder walls dry and unlubricated. If the cooling water is of a much lower temperature than the incoming air or gas, condensation is formed on the cylinder walls, with resulting poor lubrication. The answer in such cases may be to heat up the cooling water to more nearly the temperature of the intake air or gas (See Fig. 5). The

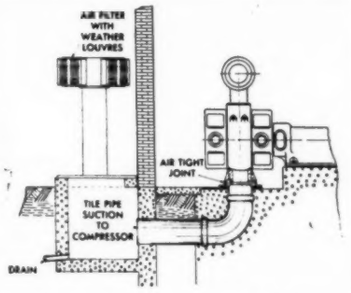


Fig. 6. The intake should be turned upward so that the air is taken from at least 10 ft. above the ground, to avoid sucking grit from the ground level, and it should be protected from the weather so that the rain is not permitted to enter

ratio of the initial and final pressures developed in cylinders has an important bearing on the oil selected, as this in great measure determines the maximum temperature prevailing in the cylinder. The size and speed of the compressor also has a considerable influence on the discharge temperature of a compressor cylinder.

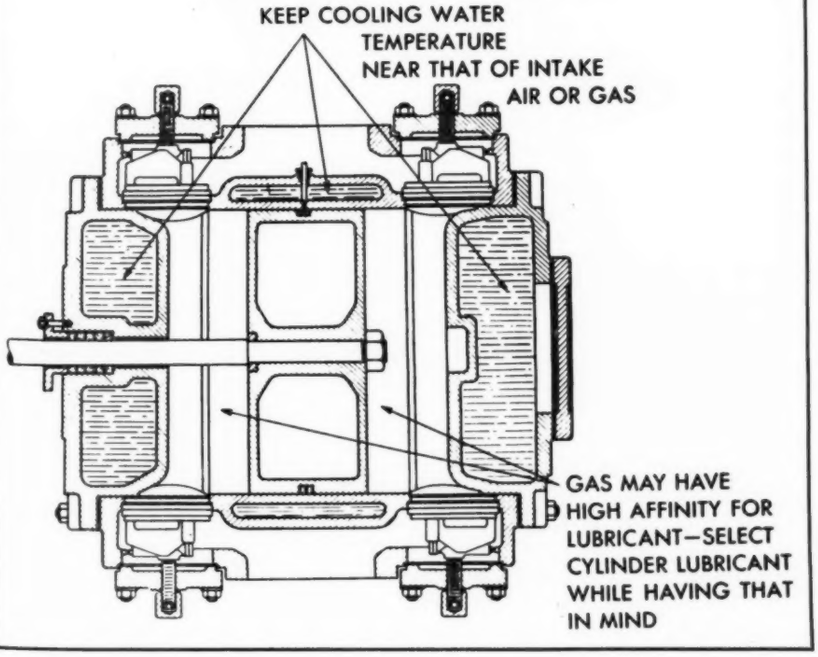
The amount of oil required in a compressor cylinder will vary somewhat with the type of machine, its speed, and local conditions of operation. It is good practice to use oil liberally while the machine is new and until the cylinders have been glazed. The quantity of oil should then be gradually reduced, using care to examine the cylinders occasionally by removing a valve to ascertain whether the walls are amply coated with oil. Provide an ample amount of oil, but do not overlubricate, as an excessive amount of oil in the discharge is very undesirable and to be avoided. Table 1 gives the minimum allowable rate of feed under ideal operating conditions, but the use of this table should be amplified by frequent examinations of the cylinder walls as previously stated.

TABLE I

Cylinder diameter, in.	Piston displacement per cylinder, cu. ft. per min.	Swept surface per cylinder, sq. ft. per min.	Oil feed per cylinder	
			Drops per min.	*Pints per 10 hr.
Up to 6	Up to 65	Up to 500	2 d. in 3 m.	0.05
6 to 8	65 to 125	500 to 750	1	0.075
8 to 10	125 to 225	750 to 1100	4 d. in 3 m.	0.10
10 to 12	225 to 350	1100 to 1500	1-2	0.112
12 to 15	350 to 600	1500 to 2000	2-3	0.188
15 to 18	600 to 1000	2000 to 2600	3-4	0.262
18 to 24	1000 to 1800	2600 to 3600	4-5	0.338
24 to 30	1800 to 3000	3600 to 4800	5-6	0.412
30 to 36	3000 to 4500	4800 to 6000	6-8	0.525
36 to 42	4500 to 6500	6000 to 7500	8-10	0.675
42 to 48	6500 to 9000	7500 to 9000	10-12	0.825

*Figures in last column are based upon 8000 drops per pint at 75°F.

Fig. 5. The temperature of the cooling water should be as close to the temperature of the air or gas in the compressor as possible, to minimize the condensation on the cylinder walls


KEEP COOLING WATER TEMPERATURE NEAR THAT OF INTAKE AIR OR GAS
GAS MAY HAVE HIGH AFFINITY FOR LUBRICANT—SELECT CYLINDER LUBRICANT WHILE HAVING THAT IN MIND

Steam cylinder oil may vary appreciably, depending upon steam temperature. For moderate steam temperatures, the following specification is submitted as taken from the *Trade Sandards:*

Flash point, 500°F., minimum.

Viscosity S.S.U., at 210° F., seldom less than 100.

Pour point, 80° F., maximum.

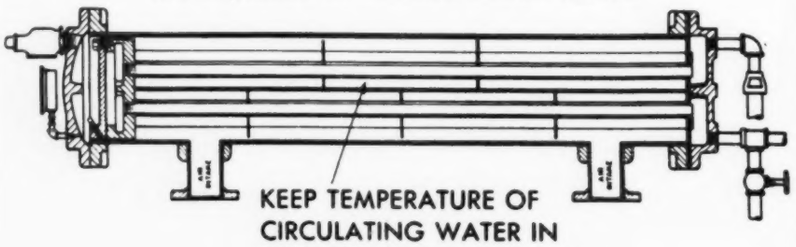
Conradson carbon residue left on evaporation, 4.5 maximum.

Compounding, 0 to 12 percent maximum.

Entirely different considerations are required for the lubrication of both rotary compressors and centrifugal compressors and exhausters. Most of the different types of rotary compressors and vacuum pumps employ different lubricating specifications. It is important to follow the instructions of the manufacturer carefully.

Centrifugal compressors and exhausters require bearing lubrication only, and in overhung units that have no bearings of their own, only the driving mechanism is lubricated. Ball or roller type anti-friction bearings on small pedestal or multi-stage units re-

Fig. 7. Circulating water in the aftercooler should be at as low a temperature as possible for maximum moisture removal



quire grease or oil in the usual manner. Larger and higher speed units generally have pressure lubricated sleeve bearings. Consult the manufacturer for recommendations.

Auxiliaries

A compressor cannot give the high standard of service necessary to meet maximum demands unless the auxiliaries that make up the complete compressed air plant, such as piping, aftercooler, and receiver, are properly designed and installed.

Beginning with the intake, it is important that the air be drawn from as cool and clean a location as possible. The weight of air handled by a compressor varies inversely as the absolute temperature of the intake. Therefore, if the intake can be reduced from 80 to 60° F., the compressor will handle about 3.75 percent more capacity. If dust or foreign matter is continually sucked into the machine, it causes rapid wear of the working parts, which means high maintenance and interruption to service. Fouling of the intake may occur if the line-opening is near a stack exhausting smoke, fumes, and dust particles, a railroad line, a coal or ash bin, or a crushing plant.

Efficient intake filters should always be installed on the compressors, and the operating log should call for cleaning the filters at stated periods. The intake should come from outside the building where the air can be obtained as cool as possible. It is often beneficial to have the air intake near the roof of the building, if the air is of better quality at that point, or on the north side of the building rather than the hot side, if convenient. The intake pipe should be turned upward so that the air is taken from at least 10 ft. above the ground, to avoid sucking grit from the ground level, and should be protected from the weather so that rain is not permitted to enter (See Fig. 6).

The intake piping should be as short and direct as possible, with long radius elbows where necessary. If not over 12 ft. in length, the intake pipe diameter should equal the diameter of the opening of the compressor cylinder; if the pipe is longer, its diameter should be increased to the next size larger.

The necessity for thoroughly cleaning suction lines cannot be over-emphasized. Welding shot, scale, or other foreign matter when pulled into a compressor frequently is the cause of serious damage to the compressor cylinder. Always make certain that this pipe has been thoroughly cleaned. The frequent finding of a pair of overalls in the suction line is not just a myth!

If a large cement tunnel is used for the suction line, it should be carefully glazed and surface treated to insure

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PAGE WELDING ELECTRODES

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against cement dust being pulled into the compressor.

Above ground, the pipe should be of standard steel or spiral riveted; below ground it may be of glazed vitrified clay with all joints carefully cemented to make them water tight.

Discharge lines should be of ample size, for lines of too small diameter result in excessive pressure drop. Larger pipe lines are especially desirable where the air lines are long. Sharp bends and elbows also increase the friction loss and should be as few as possible.

Air from the compressor discharge contains moisture, which is deposited as the air is cooled while traveling through the lines. The presence of water in the lines is harmful as it may cause leaks at the joints or freeze in the pipes in exposed places. The major danger, however, occurs to pneumatic tools where the water, by washing off the lubrication, causes excessive wear of the tools, and otherwise interferes with their normal operation. Water in the compressed air causes a loss of man hours where the air is used for blowing chips, etc., as the operator must blow the lines free of water before he can use the air.

Aftercoolers are installed to remove as much of the moisture from the compressed air as possible at the compressor before it enters the main lines. It is obvious that the amount of moisture that can be removed by the aftercooler depends largely upon the temperature of the cooling water. Therefore, the circulating water for the aftercooler should be at as low a temperature as possible for maximum moisture removal. (See Fig. 7.) It is also obvious that if the air in the air lines is cooled by room temperature to below the temperature of the air at the outlet of the aftercooler some additional moisture will be precipitated in the air lines, however, the amount is usually small.

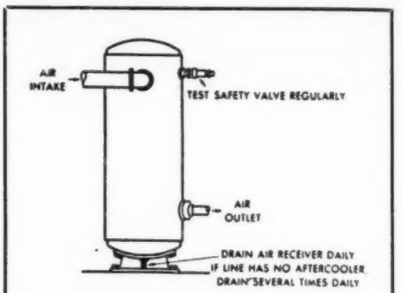
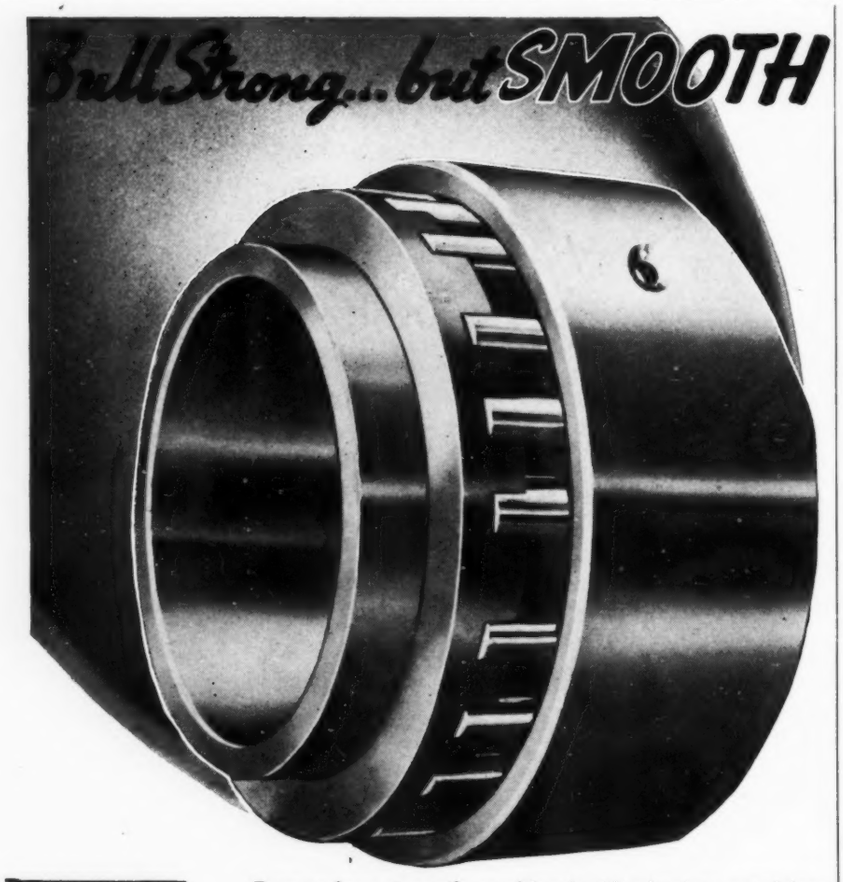


Fig. 8. The drain cocks at the bottom of air receivers must be drained daily, but if aftercoolers are used in the system, the receivers should be drained several times during the day

The aftercooler should be placed as near to the compressor as possible and a receiver of liberal size installed directly beyond. The receiver is helpful in taking care of instantaneous peaks but its use is primarily to eliminate pulsations in air lines and permit a steady, mean velocity through them. As a result, the air line beyond the receiver may be smaller than the line between the receiver and the compressor; the latter should never be choked down. Receivers should also be placed in the various departments where the air is used, if these are some little distance away from the compressor house, in order to give a constant supply of reasonably dry air.

All air receivers have drain cocks placed near the bottom that must be drained daily, or, if no aftercoolers are used in the system, the receiver should be drained several times per day on damp humid days when the air contains a maximum of moisture. Safety valves on receivers should be tested occasionally by lifting the valve levers or raising the pressure to operate the valves, to insure their being in proper condition (See Fig. 8).

A shut-off valve should never be placed in the line between the compressor and the receiver unless a safety



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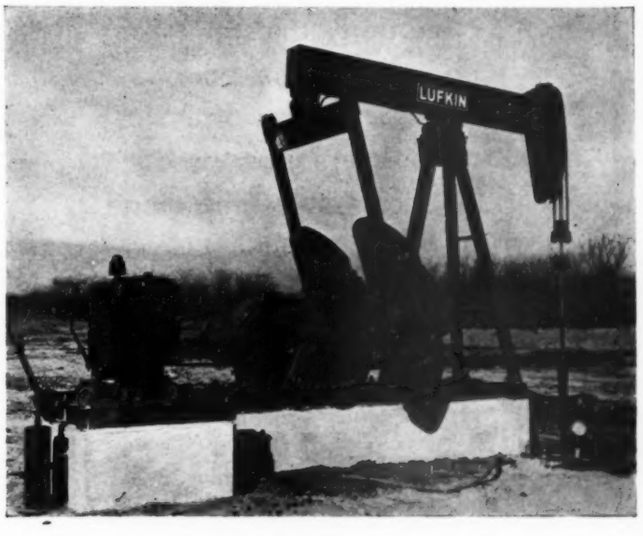

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valve is placed on the compressor side of the shut-off valve. Operators forgetting to open the shut-off valve when starting the compressor, may cause serious damage to the machine (See Fig. 9). For the same reason, it is necessary to install a safety valve between the compressor and the first shut-off valve in the pipe line, if the compressor is connected into an air main with other compressors.

Leaks in the piping system are perhaps one of the most common and most easily corrected losses in a compressor plant. Air leakage, unlike many other forms of pipe-line leakage, is easily found due to the noise of even a small stream of escaping air. The financial loss from leaks in compressed air lines can assume considerable proportions. The leakage of air at 100-lb. pressure through a single $\frac{3}{8}$-in. orifice would amount to roughly 6,000,000 cu. ft. per month; at 6 cents per M. cu. ft., this loss would amount to $360 per month. Air lines, air hose, shut-off valves, and other connections should be tested when the plant is not in operation, by packing the lines and shutting down the compressor to see how rapidly the pressure drops.

There are, of course, various ways of testing for leakage, such as holding a candle flame close to the joint to see whether the flame will flutter; soapy water may be swabbed around the joints, and, if there is a leak, it will produce a soap bubble (See Fig. 10).

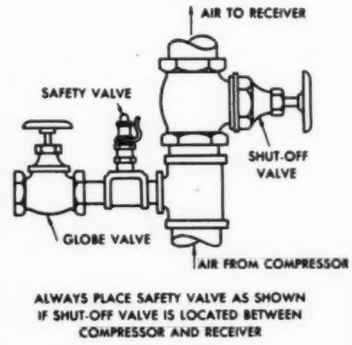
AIR TO RECEIVER
SAFETY VALVE
SHUT-OFF VALVE
GLOBE VALVE
AIR FROM COMPRESSOR
ALWAYS PLACE SAFETY VALVE AS SHOWN IF SHUT-OFF VALVE IS LOCATED BETWEEN COMPRESSOR AND RECEIVER

Fig. 9. If a shut-off valve is placed in the line between a compressor and receiver and a safety valve is not also inserted as shown, serious damage to the machinery may occur

All air hose connections should be made from the top of the distribution lines so that the hose will not pick up any moisture that may lie in the bottom of the line. The air line should be blown out well before it is connected to a pneumatic tool. On most air lines, high-pressure hose couplings are required. To maintain the hose in proper condition, it should be turned end-for-end occasionally. All kinks should be avoided, but, when they do occur, they should be carefully untwisted. The hose should be kept on racks when not in use.

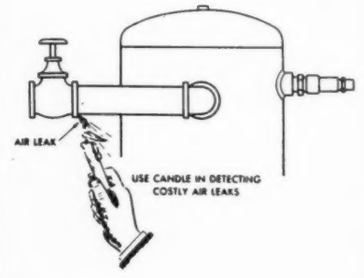

Fig. 10. A candle flame may be used to detect leaks in air lines. To test for leaks in gas lines, soapy water may be swabbed around the joint, and if there is a leak, it will produce a soap bubble

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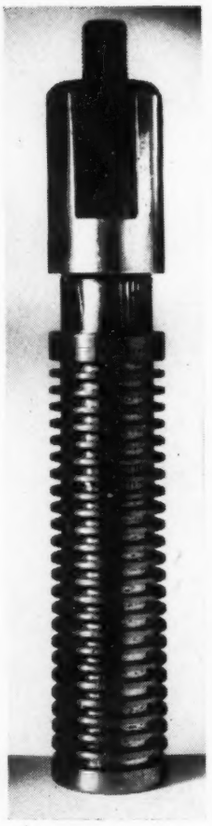

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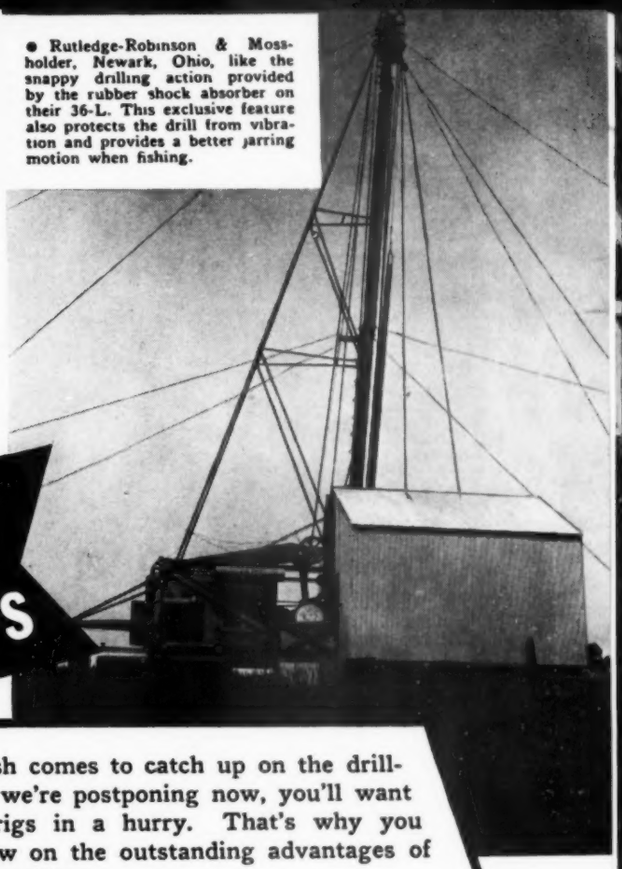

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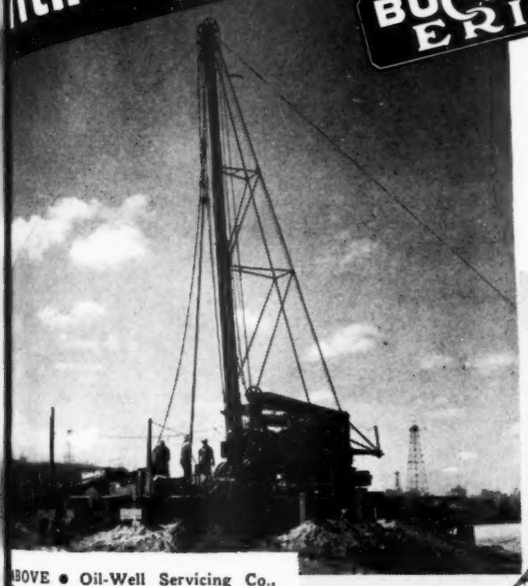

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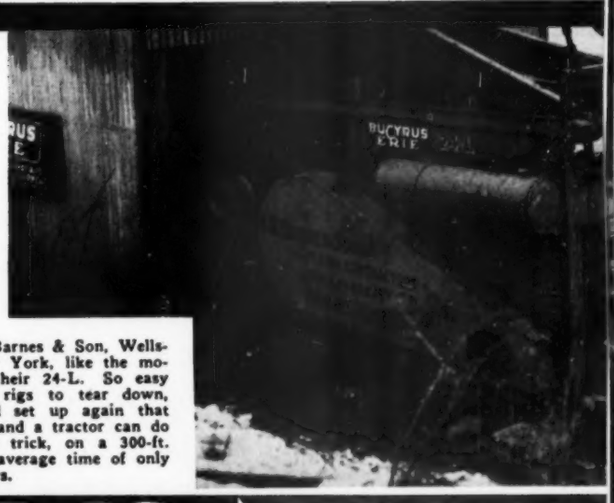

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Portable Rigs Help Meet California's Demand For Heavy Oil

PETROLEUM ENGINEER Exclusive Feature

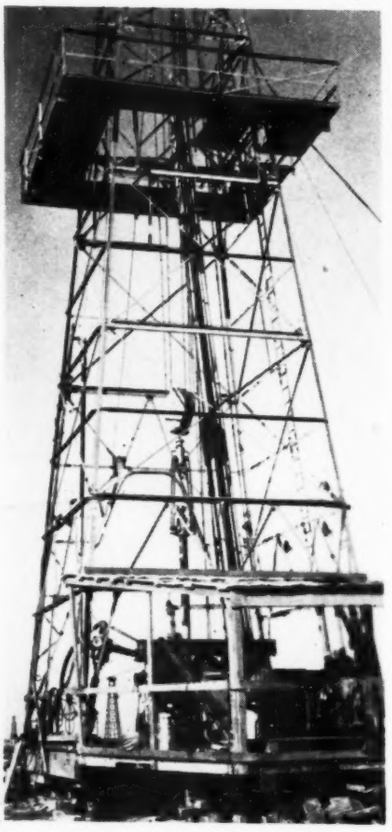
Wells in shallow fields completed rapidly and efficiently in campaign for quick supply of heavy oil

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

THE call for increased production of heavy oil in California to meet the demand for residual fuel oil has resulted in further development of many of the older producing areas. Many of these areas are in the shallow fields of the San Joaquin Valley and include such historical cynosures as the Old Coalinga field, pools in the Midway-Sunset area, Kern River, and South Belridge. Then there is the lately discovered Williams field, which is being rapidly developed. Well depths in this campaign for a quick supply of heavy oil range from a few hundred feet to nearly 4000 ft. with the majority less than 2000 ft. By the use of modern drilling equipment, particularly of the portable type, and of advanced drilling technique, these wells are being completed both rapidly and efficiently. Despite the present necessity of using salvaged casing and liner and overcoming other difficulties imposed by war conditions, completions have been made efficiently, as is evidenced by initial productions, which have been surprisingly large in many of the old fields where numerous locations are surrounded by greatly depleted wells.

Completion Methods

Many of the completions have been made in the simplest manner possible but subsurface conditions in some fields have made necessary more complex procedures. Wall-scraping has been used to a considerable extent throughout the various fields since the re-development phase began about a year ago. The main objectives of wall-scraping are to enlarge the hole for the liner and to remove the mud cake from the wall of the hole. The scraping is done after the water string has been cemented and immediately before running the liner. To what extent wall-scraping has been instrumental in obtaining better production cannot be determined accurately in many of the areas. In one field, however, one well in six was not wall-scraped and it was the only one of the six that did not flow. Subsequent wells in this field have been wall-scraped. In other fields the opinion of the operator determines whether the productive zone is to be wall-scraped, but most of the major companies scrape the sand in all wells. The small additional time and expense of wall-scraping is generally considered warranted if only a small increase in production results. Moreover, with salvaged liners being used largely and with some liner strings made up of two or more sizes of pipe it is good insurance to make certain that the hole will provide adequate clearance.



The "Diddlebug" rig, made entirely of salvaged material

Careful attention is paid to the mud fluid, as good wall-building properties are necessary to minimize water loss when drilling through the producing sands, which, in most cases, are of a character that would be easily injured even by small amounts of water infiltration. In a number of operations either oil or an oil-base drilling fluid is used for circulation while drilling the sands and while wall-scraping.

San Joaquin Valley

The diversity of methods used in completing the shallow, heavy oil wells in parts of the San Joaquin Valley is manifest in one field where four different companies are using four different methods and one other company is using two methods because of the subsurface conditions encountered in different parts of the field. Changes are, of course, made when experience shows that they may be advantageous and although the tendency is to simplify to the greatest extent possible, the effectiveness of the completion method is of first importance. When the conventional procedure of cementing a water string and running a liner will meet the conditions the speed of drilling and completing is great. In some wells the liner is cemented through the sand and then gun-perforated. In practically all cases the material available has to be taken into account and made to meet the requirements.

The methods used by one company to meet different conditions in the same field are shown in the accompanying drawings. The well shown in Fig. 1 is on one side of the field where there are no intermediate water strata to take care of. An 8⅝-in. water string is cemented on top of the oil sand and a 7⅝-in. hole drilled through the sand. The hole is then wall-scraped to 9¾-in., 14° A.P.I. gravity oil being used for circulating fluid in the scraping operation. A 6⅝-in. liner is hung, tubing run, and the well put on production.

On the other side of the field where an intermediate water sand has to be shut-off, wells have been completed as

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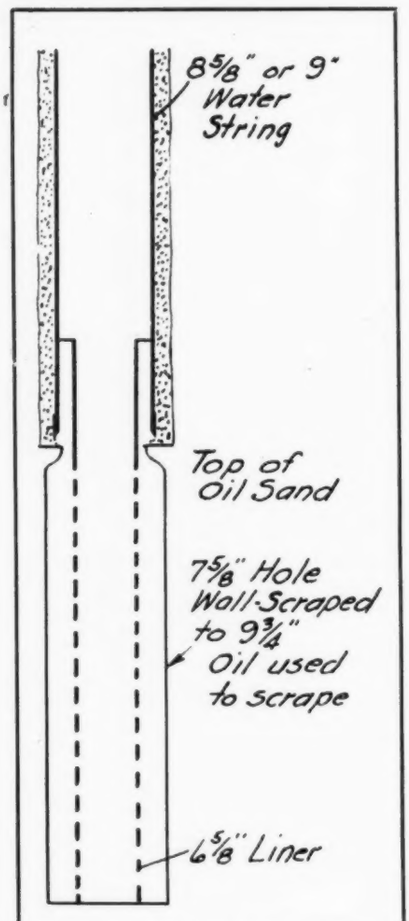


Fig. 1. Well in which there was no intermediate water strata

indicated by Fig. 2. In these wells the 8⅝-in. casing is cemented on top of the producing zone and 7⅞-in. hole is drilled through an upper oil sand, through intermediate shale and water-bearing strata, and on through 100 ft. of oil sand below. This entire hole from approximately 700 to 1100 ft. is wall-scraped to 9¾ in. A 250-ft. liner composed of 6⅝-in. pipe with the lower 100 ft. perforated is set on bottom. At the top of the perforations is a whirler cementing collar with a concrete baffle and cementing basket below the ports. The upper 150 ft. of the string is blank pipe, at the top of which is a bored-out adapter with left-hand threads. This section is run to bottom on drill pipe with a tail pipe on which are inverted swab cups. After unscrewing and cementing, the drill pipe is raised until the swab cups are just above the top of the liner and circulation then established to make sure there is no cement in the top of the liner. The drill pipe is then pulled out of the hole.

The hole between the shoe of the casing and the top of the liner is further wall-scraped to 10¾ in. Enough 6⅝-in. perforated liner to lap into the water string is then run in and set on top of the cemented blank section of liner, a turned-down nipple being on the bottom of this section. The liner is cleaned out down to the cementing collar and is shot and tested for water shut-off. If the water shut-off is satisfactory, the cement baffle below the collar is drilled out and the well put on production.

Some companies are using combination strings equipped with whirler cementing collars, with perforated nipples and cement baffles, or with similar equipment, at the cementing points. There are, in fact, many and devious variations in completion methods and these range from the most complex as shown in Fig. 2 to the simplest one of cementing a water string on top of the sand, drilling through the sand, and setting the liner. In one field where the conventional method is followed, the sand is wall-scraped to 10 in. to take 6⅝-in. liner. Although this seems a rather large hole for that diameter liner it has been found that a hole of such size is necessary to make the well flow in this particular field. Some of these wells, which average about 2400 ft. in depth, are also equipped with packers between the tubing and liner.

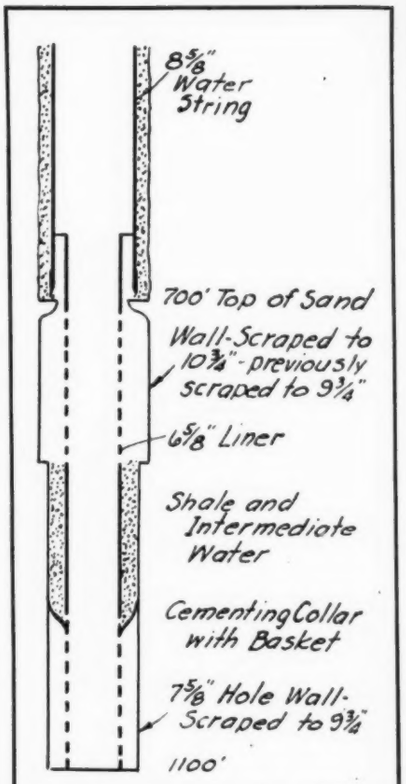
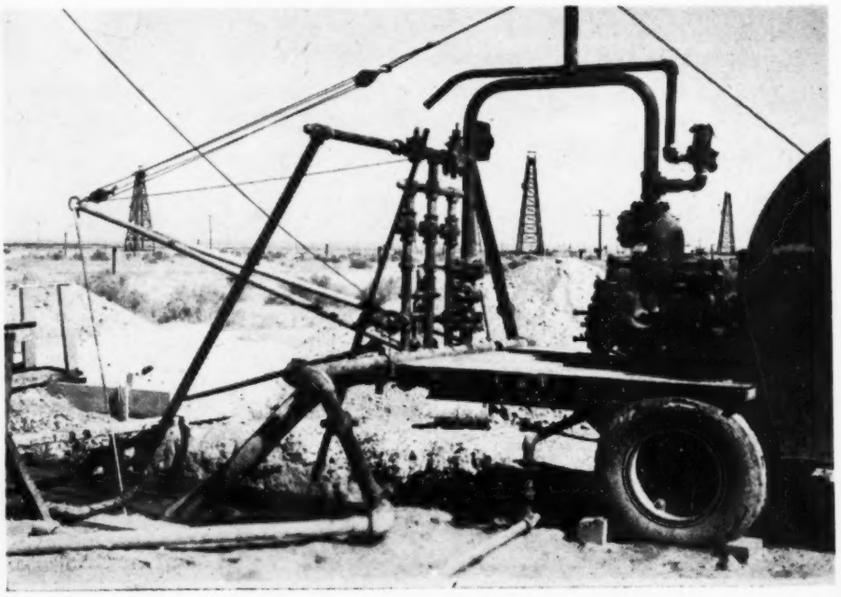


Fig. 2. Diagram of well in which an intermediate water sand had to be shut-off

Drilling Rigs

There are probably few makes and designs of portable drilling outfits not in service in these shallow fields of the San Joaquin Valley. Speed in rigging up, drilling, and dismantling seems to be the watchword. Most of the portable rigs are capable of drilling to 4500 ft. or more, so all the shallow fields are well within the capacities of the equipment employed. Several of the rigs being used have been developed and designed by or for some of the individual companies. Hoisting structures range from masts of various lengths to 90-ft. steel derricks,

The electric-motor-driven pump unit has here been hooked-up for service. Note the convenience for making and breaking connections



Not even the best 3000-lb. test drilling control equipment can be expected to seal safely against pressures usually encountered below 7000 feet. Accepted practice of most safety-conscious operators in selecting drilling control equipment: Cameron 4000-lb. test pressure-operated units for drilling depths to 7000'; Cameron 6000-lb. test pressure-operated units for drilling depths below 7000'. According to our records, no *adequately* Cameron-ized well has suffered a blowout due to failure of that equipment.

From the standpoint of wartime alertness to prevent the loss of a single pound of critical steel drilling machinery or the loss of a single pound of valuable reservoir pressure, it behooves every operator to check and double check his drilling control equipment. Replace old and inefficient models with Cameron pressure-operated units. Inspect drilling control units frequently for worn parts that might fail at the crucial moment. Rely less on mud weight . . more on control units of sufficient capacity and proven sound mechanical design.

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some of the latter being skidded from location to location. Two companies use 74-ft. steel derricks that have been made into virtually portable units.

There are more spark-plug outfits than any other kind, but several electric-motor-driven rigs are being used and there is at least one steam portable. The spark-plug engines for hoist and rotary machine probably average 250 to 300 hp. and practically all pumps are power pumps driven by their own motors. The pumps are all big and are capable of delivering more volume and pressure than operations would seem to demand.

Most of the drilling outfits are of the completely portable type that can be moved over highways as well as from location to location within the field. Among these are jackknife types, two-legged portables, hydraulic-operated masts, and various other designs that have been developed by manufacturers to provide operators with portable rigs to meet such conditions as found in the shallow operations now being conducted in the San Joaquin Valley. These outfits can be used for workover jobs and all kinds of repair work as well as drilling.

Some companies, however, have designed derrick rigs that, although not entirely portable, can readily be moved from location to location in a field where a number of wells are to be put down. An example of this type equipment is the "Diddlebug" constructed by the General Petroleum Corporation and shown in accompanying illustrations. This is an electric-motor-driven outfit and was constructed of salvaged material collected from the coast near Ventura, from San Joaquin Valley operations, and from the Los Angeles Basin fields. Its use to date has been confined to the South Belridge field.

The portable pipe rack used with the "Diddlebug" outfit is here being moved to position for drilling operations

This entire rig, including derrick, drawworks, pipe rack, electrical control unit, and mud pump, is mounted on wheels and tractor tracks. The derrick is of the regular 74-ft. steel type mounted on a large V-frame made of 14-in. steel beams, the point toward the drawworks end. There is one tractor track under each front derrick leg and two tracks under the drawworks. When this unit is moved it is pulled by a large bull-dozer at a speed as fast as an ordinary walk. It takes approximately one hour to move to a new site two locations away. Under normal conditions the outfit can stop operations at one well and be actively drilling at another location in six hours. The machine has actually completed 7½ wells in a 30-day period. The feature in this type of rig is that it does not have to be dismantled at all in order to be moved from one point to another.

A somewhat similar design being used in the South Belridge field is powered by spark-plug motors. For moving the derrick-drawworks unit of this outfit, a plank track is laid and the unit skidded on rollers on this track. Another design employs Athey wagons to support some of the units making up drilling rigs that confine their operations to one field.

Most of the wells drilled with the "Diddlebug" have been from 1000 to 1100 ft. in depth and the drilling of 7½ wells in 30 days gives an average per well of four days. This includes moving and what little rigging up and dismantling is necessary with an outfit of this kind where most of the equipment remains in place during transportation. The speed of drilling, however, is very fast with all types of rigs being used in the various field. In the Kern Front area, for example, the drilling time for wells averaging approximately 2800 ft. is from six to seven days. All types of rigs have been successful and the extensive operations now being carried on have proved the value of the portable rig to meet the demand for many wells, efficiently drilled and completed, in a very short time.

EDITOR'S NOTE: Photographs are by courtesy of General Petroleum Corporation.

☆ ☆ ☆

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I'm just an electrode, I humbly admit,
But nevertheless I am doing my bit;
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Without me you never will get anywhere,
So please, Mister Welder, conserve me with care.
In storage insist that I'm always kept dry,
Up off the damp floor on a shelf amply high.
Beware sweating pipes, open windows, and such,
I sometimes am rusted by moisture's least touch.
Then if through some mishap I chance to get wet,
Just spread me out quickly. And please don't forget
That I do my best work when I am not bent,
And fit all joints properly 'ere you consent
To do any welding, and then for best strength
Make legs of all fillet welds equal in length,
And, too, make the face of all fillet welds flat.
Since I'm growing scarce, it's now urgent that
To win in this conflict with gun, plane, and sub,
I'm utilized down to the tiniest stub.
Produce everlastingly! Use me! Don't cease!
We'll then win the war and the right kind of peace.

—W. F. SCHAPHORST.

RIGGING-UP AND OPERATING PRECAUTIONS

★ 1. Keep sand, shale, gas, and air out of the drilling mud.

★ 2. Make sure that the suction line (a) slopes gradually and uniformly from the slush pit to the pump; (b) has *no* air pockets; (c) provides minimum suction-lift; and (d) is as large as the pump's suction connection.

★ 3. Use a flexible suction hose. It acts as a shock absorber and eliminates excessive strains on flanges.

★ 4. Use a suction strainer to keep sticks and other debris from fouling the valves or plugging the bit. "OILWELL" suction strainers are amply oversize and easy to clean, and are furnished in straight and right-angle types.

★ 5. Use lip-type self-sealing packing for fluid pressures over 750 pounds per square inch. Be careful not to adjust the stuffing-box glands too tightly with this type of packing. Oil lubrication prolongs packing and rod life and is rapidly gaining favor over water lubrication.

★ 6. Use a pressure-relief valve in the discharge line to protect a power pump. Set it to release at not more than one-and-a-half times the maximum recommended operating pressure for the liner size in use.

★ 7. Avoid the use of tees and short-radius bends in the discharge line. They build up "non-useful" pump pressure. "OILWELL" long-radius ells and goosenecks are heat-treated and reinforced against wear and are furnished in 3- and 4-inch pipe sizes.

★ 8. Use a lubricator that is big enough to run from one regular filling to the next. Make sure that all lubricants are of the proper grades for prevailing temperatures and other operating conditions.

★ 9. Keep lubricating oils and greases clean. Use clean containers, and make sure that the lubricator is equipped with a strainer of adequate capacity.

★ 10. Operate a steam pump with dry or superheated steam if possible. This is desirable from the standpoint of proper lubrication as well as efficient, snappy performance.

★ 11. Drain both steam and fluid ends when shutting down for an extended period. Drain fluid ends above the discharge and suction valves.

★ 12. Keep power-pump tapered roller bearings adjusted for proper running clearance, but avoid setting them up too tight. Adjustment must provide for temperature expansion. Proper adjustment will maintain efficient performance and minimize wear, which would increase rapidly in loose bearings and cause impact shock loads.

★ 13. If a pump knocks, examine the suction line and connections first. Knocks are usually due to suction leaks or restrictions. If the source of the knocking cannot be located in the suction of a power pump, then check the bearings.

★ 14. Keep valve covers and cylinder heads uniformly tight with normal stud tension. Nuts should always be tightened by progressing from one stud to another diametrically opposite—never in rotation around the flange. Never take up more than a quarter turn with a wrench before progressing to a nut on the opposite side. Making up a nut or nuts "wrench tight" on one side and then pulling down on the other side usually results in breakage of studs and damage to the gaskets.

★ 15. Priming when starting will save pistons.

★ 16. *Remember, a clean pump runs better.*

REGULAR INSPECTIONS AND ADJUSTMENTS

At the Beginning of Each Tour:

1. Fill lubricators and check to make sure that lubricating oil is being delivered in proper quantities to all necessary points. Lubricate all grease-packed bearings, and check crankcases of power pumps.

2. Listen for the tell-tale noise of leakage inside the fluid end. Many liners, valve seats, and even fluid ends have been saved by detecting leakage in time.

3. Check outside liner adjusting screws for possibility of takeup. New "OILWELL" heavy-duty slush pumps are equipped with Type "HD" Liner Spacers, including single, external, roller-bearing adjusting screws. Type "HD" Spacers can be installed in the field on many "OILWELL" pumps not having them as original equipment.

4. Turn steam-pump piston rods one-quarter turn to distribute rod, piston, and piston-ring wear.

5. Inspect all stuffing boxes. Adjust glands evenly and keep them no tighter than necessary to prevent leakage. Replace worn bushings promptly, as a close fit is required to prevent extrusion of packing. A braided copper ring next to the gland is effective in preventing extrusion of packing from steam-end stuffing boxes.

Once Every Week:

1. (a) Examine the fluid valves, inserts, and seats. Valve and seat life can be substantially prolonged by renewing inserts in time. (a) Shift the discharge valves to the suction valve positions and vice versa. (c) Replace all valve cover gaskets which do not extend at least 1/16-inch out of the grooves in the caps.

2. Clean suction and discharge strainers to prevent flow restrictions. The discharge strainer should also be cleaned every time a valve insert or piston rubber tears loose.

3. Replace the shear pin in the pressure-relief valve. This pin fatigues in service and will fail below the desired pressure if not replaced at regular intervals.

4. Check tightness of all screws and bolts in the power end.

Reprints of this advertisement are available for posting in pump sheds, tool houses, and field offices. Write Dept. P., Oil Well Supply Co., Dallas, Texas.

OIL WELL SUPPLY COMPANY

P 934.314.
P 934.35

Employee Training Helps Solve Problem of Manpower Shortage

PETROLEUM ENGINEER Exclusive Feature

☆ Making of unskilled or semi-skilled workmen into skilled workmen in shortest time possible is essential

by A. W. Breeland

Supervisor of Safety, Lone Star Gas Company

ALTHOUGH the pipe-line industry has suffered seriously as a result of material shortage, there is no question but that the most serious shortage suffered is that of manpower.

A considerable part of the male employees of the natural gas pipe-line industry has been removed from its ranks either by the several branches of the armed services or by war industries. How to maintain sufficient skilled employees to carry on the operation and maintenance of natural gas pipe lines has been a difficult problem for which there appears to be no complete remedy for the duration. Materials and equipment are difficult to obtain but skilled workmen have also become difficult to obtain. Therefore, if facilities that are being taxed to the utmost to meet war requirements are properly to be maintained and operated, a sufficient number of skilled workmen must be made available.

It has been possible of course to recruit some employees, but very few skilled employees have been available. Each company, therefore, must depend on its own personnel for skilled workmen. This means that a job-training program that will transform the unskilled or semi-skilled workman into a skilled workman in the shortest possible time is essential.

It may be stated generally that in the past a great deal of our employee training in the field has been by the trial and error method. Training by this method or in this manner is very costly. It is expensive to the employer in loss of production due to inefficiency, increased insurance costs, and waste of material, and it is likely to be expensive for the employee because of accidents that frequently occur due to lack of proper training.

Better and Quicker Training

Because of the acute shortage of manpower, it will be necessary, if the industry is not to suffer too severely, to do a better and quicker job of employee training. The first step in employee training is to prepare the foreman for the task of giving the actual job training. As has been stated, in the past nearly all field employees in the natural gas industry learned their jobs the hard way, which is also the long way, foremen included. In order for him to do a better training job, it is necessary that the foreman know more scientific methods of training. He certainly must know his own job and how to do the various jobs for which he is responsible before he can do a real job of employee training. If he knows how to do the various jobs and how to make a breakdown or analysis of each job, then he knows the logical steps to take in accomplishing the job of employee training. If he does not, then he must be taught how to make a job breakdown or analysis before he is in position to teach correctly one of his own employees to do a given job.

In our own organization we have given all our supervisors and foremen information that should enable them to be better prepared to analyze a job and properly to teach an employee how to perform it. This information was given in supervisor meetings as the preliminary step in employee training. It is very important that the foreman or supervisor should know how to teach because his ability to train will determine the success or failure of the entire training program.

The first requisite is that the supervisor must know the job he is to teach, and the logical steps to perform it.

The second step is to know *how to instruct*.

How to Instruct

If the supervisor knows how to instruct he will first prepare the employee by putting him at ease and by giving him a concise but complete history of the company, its policies with reference to its employees, and the part it has to play in the war program. He will then

A. W. BREELAND

entered the gas business in 1922, when he joined Lone Star Gas Company as clerk in the gas measurement department—Was later made chief clerk in the gas operating department, and in May, 1929, was appointed supervisor of safety for the company and organized the company's accident prevention training system—Prior to his connection with Lone Star, Breeland was with the M-K-T Railway in Wichita Falls and Dallas—He is a native of Mississippi, was educated in the schools of Pike and Walthall counties, Mississippi, and in the Tri-County Normal School of McComb City, Mississippi—Having completed his teacher's training, he taught school for one year and then enlisted in the U. S. Army for service during the World War—During his enlistment he studied one semester at the A. E. F. University at Beaune, France—Completed a business course in bookkeeping and shorthand at Tyler Commercial College in 1919-20 and later enrolled for and completed the following correspondence school courses: Higher Accounting with LaSalle Extension University; Business Administration with Alexander Hamilton Institute—Has served as a member of the Dallas Citizens' Traffic Commission, the State Commission on Apprentice Training and Vocational Education—Is general chairman of the Central Committee on Accident Prevention of the American Petroleum Institute, as well as chairman of the Advisory Committee of that body—Is a member of the American Gas Association Accident Prevention Committee, being also a past general chairman of that committee; and a member of both the Texas Safety Association and the American Society of Safety Engineers.

Electroweld Tubing

SAVES IN WEIGHT AND IN FABRICATING COSTS

THE latest type electric weld tube mills are found at Electroweld Steel Corporation. The accuracy and dependability of this equipment coupled with the most modern testing facilities permit production of a product with three distinct benefits—safety, savings in weight, and savings in cost.

This equipment forms tubing from strip steel which is rolled accurately to gauge. Thus the wall thickness is uniform, and lighter gauge material may be used without sacrificing strength. As a result, there are no thin spots in the wall of Electroweld Tubing, and you save weight. The strip steel meets your specifications accurately, and after it is formed into tubing the strength at the weld and adjacent areas will equal that of the strip steel. Every foot of Electroweld Tubing is hydrostatically tested for safety. Therefore, it not only meets your specifications but also Government requirements.

Electroweld Tubing may be adapted economically to boiler, heat exchanger, and condenser installations as well as to mechanical applications since it may be cut, formed, and welded more easily. During the post-war period, you will find it worth-while to consider Electroweld Steel Corporation YOUR source of supply.

Electroweld STEEL CORPORATION • OIL CITY, PA.

Manufacturers of pressure and mechanical steel tubing

place him in the correct position to receive instruction and proceed to present the operation. Placing the new or the old employee in the right position to receive instruction is extremely important and is one point often overlooked. The worker should be on the same side of the bench, machine, or desk as the instructor so that he will see the job or operation from exactly the same angle as the instructor, instead of looking at it backwards as he would if placed across the desk, bench, or machine from the instructor.

In presenting a job to a new employee, and attempting to teach him how to do it, the mistake of telling him *only* is too often made. Very few people will be made to understand a job by merely being told how to do it, even when told slowly and patiently. The employee must be told how to do it, shown how to do it, and then allowed to perform the job under the observation of the instructor until he is able to do it correctly. The foreman should follow up on the worker at intervals to make sure that he understands thoroughly and has developed the manipulative skill necessary to the efficient performance of the job.

There are some jobs in the industry, however, that require deviation in the instructional procedure, for instance, repairing pipe line leaks under pressure. As scarcely any two leaks are exactly alike, it is somewhat difficult to give as specific information on leak repairs as on more standardized procedure jobs. We can and we should give general job training on the procedure to be followed in digging the leak out, assembling material for making the repair, accurately determining whether the leak is one that may safely be repaired under full pressure, under reduced pressure, or whether it will require that the line be completely shut off. This knowledge is most important for making leak repairs and at the same time the hardest to teach. Obviously, all leak repair jobs should be under the supervision of a trained and experienced pipe-line repair foreman. Greater efficiency, however, and less accidents will result if each member of the repair crew has a good understanding of the problems involved in the work.

In this same connection new men and perhaps some of the old employees must be taught the importance of all pipe with seams, such as lap and butt weld, being laid with the seam in the upper quadrant of the line. When rubber couplings are being used, the weld or seam of the center ring should also be in the upper quadrant of the line.

The reason for this practice is that in the first place the seam is the weakest part of a joint of pipe and in the second place the bottom of a gas pipe line is the section of the line most vulnerable either to inside or outside corrosion. Any liquids in the line will either travel or settle along the bottom. Likewise, water and other liquids on the outside accumulate along the bottom of the ditch, increasing the possibility of corrosion on the bottom of the line.

Another operation concerning which new men should have a thorough knowledge is the operation of gate valves. This is especially true of gates with non-rising stems. It is very important that pipe-line employees should be able easily and quickly to ascertain when this type gate valve is open or closed. This of course cannot be determined by observation. Knowing the number of turns of the wheel necessary to open or close the various sizes of non-rising stem gate valves is of great importance in this training. Not all makes of gates will have the same number of turns for each size, but should more than one kind of gate be in use in one district, and the chances are that there will be several makes, then the pipe-line employee should know the number of turns necessary to open or close the several sizes of each make gate he has in his district. Impossible? Of course not —tell him, show him, and let him open and close the different sizes in each make he has to use and he will learn quickly.

Certainly this knowledge is not sufficient to train an employee thoroughly on how to operate his gate valves but it will help materially and it is more than many pipe-line employees now know about gate valves.

Use of Bonding Clamps

Of particular importance in our company training program at this time is the use of a bonding clamp to provide a continuous metallic bond in the pipe line before it is separated for repairs, removal of a joint or joints, valve, or other piece of appurtenant equipment. It is known that currents of varying magnitude and direction may flow along pipe lines. The general belief seems to be that the amount of current depends upon the condition of the pipe coating, soil qualities, proximity to other current collectors, such as pipe lines, tanks, and railways.

In the past we have had some fires where the source of ignition was never determined, although the more common sources were ruled out.

In order to eliminate one more possible source of ignition, we have now instructed all pipe-line foremen to install a bonding clamp assembly before making a break in a line so that there may be a continuous flow of any currents that might be in the line. The clamps are installed on the line before removal of a joint, gate, or other piece of equipment, by providing a clean spot on the pipe at both ends of the section to be left in place. The spot at which the contact is made should be filed clean about the size of a half dollar in order to allow a good electrical connection when the set screw in the clamp is tightened. The clamp and bonding line should remain in place until the joint of pipe or other piece of equipment has been replaced.

When replacements are being made consisting of long sections that cannot be protected with the cable available, the section may be isolated first by installing clamps at each end of the section being removed, and after the section is isolated the clamps may then be removed until ready to make the tie-in. The clamps should be in place before the tie-in is attempted.

Safety Through Efficiency

Thus far in our training program, and we plan to continue on this basis, we are stressing the importance of training new employees, and old employees on a new job, in the quickest possible time to perform their job efficiently. We believe the training program now under way will undoubtedly accelerate the training of new employees and old employees shifted to new jobs. We have not said much about safety for the very good reason that we know that if we can get an employee trained to do his job efficiently he will automatically do it safely. In other words, we will achieve safety through efficiency.

We must recognize that we no longer have a reserve pool of skilled manpower. If we are to continue to operate with any degree of efficiency, and the war program demands that efficient service must continue, we must develop our training technique to the point where we can maintain output without accidents and without impeding the war effort of our nation. We must train our industrial soldiers so that they can keep up with the pace of our soldiers on the battle front.

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...and the ...

WHILE ... are bei... let's not for... *man* who is responsible for the lifeblood ... keeps our firing lines and production lines operating at an ever increasing tempo.

He has met war requirements quickly, efficiently and cheerfully. Production and drilling schedules have been maintained in spite of drastically curtailed materials and large manpower losses. Destroyed crude supplies are being rapidly replaced. New and different products have been produced to meet changing demands. The development of synthetic rubber and hi-octane gasoline are *two* of his outstanding contributions to the war effort.

From the days of Colonel Drake, the oil fraternity's clear vision, unswerving courage and stalwart leadership have overcome such obstacles as lack of finances and equipment, inaccessible locations and transportation difficulties. In war or peace, *the oil man carries on with plenty of courage and baling wire.* And Johnston deems it an honor to be serving an industry which is contributing so much to the development of the world's natural resources.

FORMATION AND CASING TESTING — JOHNSTON

While for the duration armament production must come first, we're continuing our research and development activities so that at the war's end the oil industry will have even finer, more efficient testing equipment than ever before.

M. O. JOHNSTON Oil Field Service Corp.
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JOHNSTON Oil Field Service Corp.
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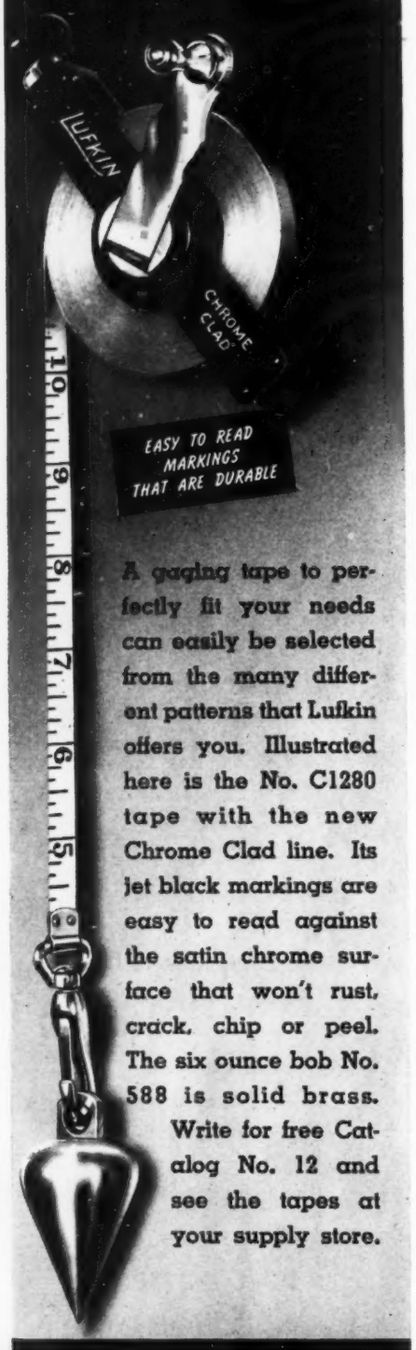
"Why set casing before you know!"

LUFKIN
OIL GAGING STEEL TAPES



A gaging tape to perfectly fit your needs can easily be selected from the many different patterns that Lufkin offers you. Illustrated here is the No. C1280 tape with the new Chrome Clad line. Its jet black markings are easy to read against the satin chrome surface that won't rust, crack, chip or peel. The six ounce bob No. 588 is solid brass. Write for free Catalog No. 12 and see the tapes at your supply store.

LUFKIN
SAGINAW, MICHIGAN · New York City
TAPES · RULES · PRECISION TOOLS

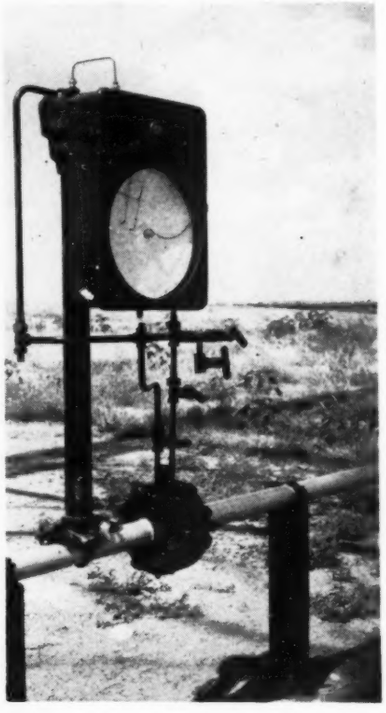
P 458.22

Solid Support For Meter Run

by J. C. Albright

THE lead line on a lease that carries gas under pressure to the tubing-head of an injection well in a pressure-maintenance project is constantly subjected to stresses resulting from expansion and contraction due to alternate heat and cold as well as the pressure in the line. An inexpensive yet substantial support for the pipe at the recording meter station can be made with two short pieces of junk pipe set in the ground at the required distance from each other in relation to the meter flange and tamped, or secured, in the holes with a concrete grout to stabilize the setting if it operates under unusual conditions. The posts may be made of any convenient size of pipe larger than the meter run with the upper ends closed by turning a part of the walls in to form a saddle-shaped cradle for the meter run piping. Threaded machine bolts are welded on each side of the saddle, allowing sufficient space between them so the meter run will rest in place without touching the bolts. Holddown clamps of strap iron welded to pipe ferrules that slip over the bolts are secured by running the nut down snugly. Small inequalities in leveling can be corrected with shims beneath the pipe at the post, which may be slightly lower than the other.

☆ ☆ ☆



Supporting posts made of pipe set in the ground on each side of an orifice flange in a small meter run to hold the instrument level and prevent distortion of the setting due to expansion and contraction

P 094.83

How To Keep Electrical Starters Operating

A PROGRAM of constant checks against oil, dirt, and moisture that enabled one large manufacturer to run 6500 electric motors for 10 years with only 10 minutes lost time due to power failures was described recently to the Electrical Association of Rochester, New York. Oil, dirt, and moisture, explained L. E. Markle, control equipment engineer for the Westinghouse Electric and Manufacturing Company, are saboteurs that ruin electric motor starters so important to plants depending on electric power to drive their machinery.

This particular plant, the group was told, adopted a vigilant maintenance program and immediately discovered that practically all its starters and other equipment needed attention. Since regular inspection and cleaning were begun, there have been almost no shutdowns. Such programs are more important than ever before, to keep the motors turning to meet the demands of war.

Close coöperation with manufacturers by motor starter users may point the way to changes in design that will reduce the need for maintenance and prevent shutdowns for repairs, he added. Re-design and improvement of a few parts have been known to increase the useful life of a complete starter for a long time. No matter how good a design may be it can always be applied to some service or in some atmospheric conditions where its performance may not be entirely satisfactory.

☆ ☆ ☆

40 miles by taxi across the Pacific

One of this war's most dramatic stories started when a take-off accident damaged the octant of this Flying Fortress. Hours later, off course, hopelessly lost and gas exhausted, its pilot landed it and the crew of seven on the open sea.

Packed into three little rubber "doughnut" life rafts, they floated for 3 weeks catching rain for water, and a fish or two for food, battling sharks, storms, hunger and thirst with unbelievable fortitude. One raft made land. A PT boat picked up the second.

A Kingfisher Navy observation plane spotted the third—3 men aboard. With room for only one in the cockpit, the others were lashed to the wings. The Pratt and Whitney Engines (equipped with American Hammered Piston Rings) taxied the overloaded plane across many miles of the Pacific to safety.

Workers in the foundry, the shop, the inspection department, all know that someone's life may depend upon each ring they make . . . which helps explain why every ring delivers that all-important last ounce of effort in time of need. Koppers Company, American Hammered Piston Ring Division, Baltimore, Md.

American Hammered Piston Rings

KOPPERS

THE INDUSTRY THAT SERVES ALL INDUSTRY

FROM WASHINGTON

Order No. 11 Replaces M-68

Petroleum Administrative Order No. 11 replacing the provisions of War Production Board M-68 dealing with petroleum production operations has been issued by Petroleum Administrator Harold L. Ickes.

Administrator Ickes said:

"This marks a major step in the simplification of administrative procedure made possible by the Executive Order establishing the Petroleum Administration for War. The production branch of the petroleum industry will find in the new order, more flexibility, simplification, and clarification than in the old order, as a result of the experience we have gained during the past year."

The salient changes in the new order are:

1. "Maintenance or Repair" is redefined to exclude any restriction because of accounting practices and to include capital additions not exceeding $500 in material costs.

2. Pumping equipment may not be installed at flowing wells prior to the time such wells cease to flow naturally, except where the wells are no longer capable of flowing their allowables.

3. "Condensate Field" is no longer defined. Instead 115 fields are specifically listed as condensate fields in which an exception is required before any drilling can be done. This list will be modified from time to time as the need requires.

4. "Exploratory Well" has been modified to exclude any well in the proved area of a gas or condensate field, regardless of distance from other wells.

5. The order permits the plugging-back or deepening of oil wells whose locations conform to the 40-acre drilling pattern established under the order, even though those wells are not the only wells on the units and are not the prescribed distance from offset wells.

6. Gathering systems may be constructed to connect wells to a pipe line provided the material costs do not exceed $2500 and provided the new installation does not duplicate an existing facility.

7. Except as provided in Supplementary Order No. 1, the drilling of all gas wells requires exceptions.

8. The new order supersedes Supplementary Order No. 5 to the old Order M-68 relating to Illinois; and also Petroleum Administrative Order No. 6, relating to the Hugoton gas field, which have been revoked.

9. In sectionalized areas, the drilling unit is redefined so that it must consist of a quarter-quarter section of at least 35 acres.

10. Secondary recovery operations, regardless of geographic location, are no longer automatically excepted. Supplementary Order No. 2 accompanying the PAW Order No. 11 provides automatic approval for secondary recovery operations in the Eastern fields. In other areas lack of concurrence within the industry as to the definition of "Secondary Recovery Operations" necessitated deletion of the automatic exemption, and an exception is hereafter required before installing secondary recovery facilities in all areas outside of the Eastern fields.

11. PAW Forms 3 and 4 will be used in connection with the new order instead of OPC Forms PD-214a, b, and c, thereby reducing the number of forms now in use.

The following Supplementary Orders were issued simultaneously with the new Petroleum Administrative Order No. 11.

(a) Supplementary Order No. 1 prescribes conditions under which gas wells may be drilled in the Appalachian area and in a specified area in Oklahoma, Kansas, and Missouri, without obtaining special authorization.

(b) Supplementary Order No. 2 provides automatic authority to carry out secondary recovery operations in the Eastern fields, and also provides specific well-spacing requirements for drilling in areas where secondary recovery operations are not carried on.

(c) Supplementary Order No. 3 provides for reworking old wells in the Smackover field of Ouachita County, Arkansas.

California and the special problems of that area are under active consideration and further announcement in relation thereto will be made in the very near future.

In the meantime, Supplementary Order M-68-3 relating to "heavy oil" operations in California has been reissued as Supplementary Order No. 4 to PAO No. 11 and will continue in force until superseded by an order incorporating a wider range of production operations.

Deputy Petroleum Administrator Ralph K. Davies said:

"The intent of the new order is to outline certain general conditions under which authority to acquire and use materials is automatically granted for use in production operations, thereby reducing paper work to a minimum. Supplementary Orders are issued to fit the operating conditions in certain fields or areas, permitting use of materials under less restrictive conditions than are prescribed in the general order. Provision is also made for granting special exceptions where special conditions warrant such action. Exceptions which have been granted under the old order are not disturbed and applications pending under the old order will be treated as applications under the new order. We cannot allocate or regulate the use of materials without some paper work, but we want to eliminate it as far as humanly possible.

"The new order imposes no restrictions on the use of material for wildcat wells. This is in keeping with our policy of encouraging a maximum amount of exploratory work to discover new reserves."

Order P-98-c Amended

To promote the free flow of materials within the petroleum industry, both at home and abroad, the War Production Board has issued an amended Preference Rating Order P-98-c.

The amended order simplifies and concentrates all controls over materials inventories in the petroleum industry, defines "Surplus Material," provides a method of accounting for transfers of material from domestic operations to foreign operations, and establishes participation on and after May 1, 1943, in the Petroleum Administration for War Materials Redistribution Program No. 2 as a prerequisite to procuring any materials for use in the petroleum industry.

(PAW Materials Redistribution Program No. 2 is now being drafted and will be announced in the near future.)

"Surplus Material" is defined as any material that is not required for use by the owner during the succeeding 90 days. The order prohibits the acquisition by any operator, for use in the United States, its territories or possessions or in the Dominion of Canada, of any materials that would result in his accumulating more than a 90 days' supply.

This limitation, plus the requirements of the PAW Materials Redistribution Program, takes the place of the inventory control requirements previously imposed by Priorities Regulations

REILLY PIPE ENAMEL

Reilly COAL TAR PRODUCTS

● The vital importance of the service rendered by America's pipe lines has been sharply emphasized by war conditions. The protection of these lines is even more essential in war than in peace. The dependable protection which REILLY Enamel gives to pipe lines has been established by years of service. This tough, durable coating prevents corrosion from moisture, electrolysis, soil acids and alkalies. It resists abrasion and soil stress, and withstands wide extremes of temperature without sagging or cracking. As a lining on water lines REILLY Enamel prevents incrustations and tuberculation and insures permanent full-capacity flow.

REILLY coal tar paints give effective, economical protection to tanks, stacks, towers, structural steel and other metal surfaces.

Booklet describing these protective coatings will be sent on request.

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SEVENTEEN · PLANTS · TO · SERVE · YOU

Nos. 1 and 13, and by Controlled Materials Plan Regulations Nos. 2, 5 and 6. Inventory control requirements in Preference Rating Order P-98-b will be revised in accordance with the provisions of the amended Order P-98-c.

The order establishes the filing of Form PD-470 with PAW as a prerequisite to the acquisition by operators from other operators of materials from within the United States for use outside the United States, its territories or possessions. This will permit the keeping of an accurate record of the materials transferred from the operating stocks of the United States to foreign operations. Thus, the books of Lend-Lease and Board of Economic Warfare will reflect all material moving to foreign operations.

Subject to the 90-day supply limitation, sales or transfers of material from one operator to another may be made freely up to May 1, 1943, provided the material is to be used in the United States, its territories or possessions.

On and after May 1, 1943, no operator, who is required to obtain a serial number under PAW Materials Redistribution Program No. 2, may obtain material from another operator or apply priorities assistance to obtain material, unless such serial number is in effect. The serial number must be clearly identified upon any document used in completing the transaction.

Not to Restrict Wildcatters

Petroleum Administrator for War Harold L. Ickes has denied that the Petroleum Administration intends to tell oil wildcatters where to explore for new wells.

The administrator said:

"Unwarranted apprehension has been expressed by certain members of the industry that the Petroleum Administration for War intends to exercise discriminatory judgment with regard to the drilling of wildcat wells. I contemplate no such action. My office has done everything within its power to avoid any restriction upon the exploratory effort of the oil industry. I propose to continue this policy."

Recently, Administrator Ickes called for the drilling of at least 4500 wildcat wells during 1943, 50 percent more than were ever drilled before in any single year.

During the last few years, the rate of production has exceeded the rate of discovery of new oil fields.

Importance of exploratory drillings was emphasized by Deputy Petroleum Administrator Ralph K. Davies. He stated:

"Exploration is more important today than it ever has been. We must find new oil fields at an increased rate if we are to continue to have a productive capacity equal to our needs.

"We are not concerned with the estimates of reserves made up largely of revisions. Our reserves are sufficient; it is our daily productive capacity that may fail.

"The quickest method of increasing the productive capacity of this country substantially is through the discovery of new fields.

"The Petroleum Administration for War proposes to do everything within its power to promote the drilling of an adequate number of wildcat wells. Where these wells will be drilled will be left, as it always has been, to the discretion of the wildcatters."

Explains California Price Increase

Action by the Office of Price Administration in raising the price of certain California crude oil was described by Acting Petroleum Administrator for War Ralph K. Davies as "an important step toward increasing the output of urgently needed petroleum war products on the West Coast."

Davies said:

"This increase in the price of California crude will make possible the rehabilitation of hundreds of existing oil wells; will encourage a great deal of remedial work on other wells, and should stimulate the development of new wells for the production of heavy oil.

"When the Petroleum Administration for War, on January 30, recommended advances in the price of California crude, we did so because we were so keenly aware of the need for enormous quantities of heavy fuel oil for the bunkering of Navy and merchant ships, and for other vital military purposes. California heavy crudes are particularly valuable in yielding the type of fuel oil so greatly needed by the armed forces. It was evident to this office, on the basis of the most careful studies by our staff and by committees of the industry, that because of increased production costs, price advances were necessary in order to increase production. Today's action by OPA will, we hope and expect, result in such increased production."

Last August, the Petroleum Administration (then the Office of Petroleum Co-ordinator for War) recommended to OPA that a survey of California heavy crude production be conducted, with a view to adjusting costs. Subsequently, a comprehensive survey was conducted by PAW's industry committee in California, which recommended the approval of higher prices.

The present price increase is expected to arrest the monthly quota decline caused by declining tendency in the productive capacity of certain California fields, Davies said. Moreover, it is hoped that the declining productive capacity of these fields will not only be arrested, but that eventually they will be increased.

Industry spokesmen say that these price increases will make it possible to open several hundred additional wells in the California oil fields, thus increasing the output of residual fuel oil.

The need for greater amounts of this type of fuel oil is being heightened by demands of the armed forces fighting in the Pacific theater. In commenting on the California crude price advance, Davies pointed out that this increase is not related to the overall crude price increase and recommended recently to PAW by the Petroleum Industry War Council and is without prejudice to that issue.

Organizational Planning Staff Formed

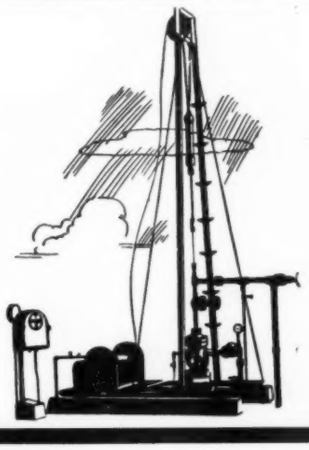
The setting up of an Organizational Planning Staff in the Petroleum Administration for War, with Lounsbury S. Fish in charge as director, has been announced by Deputy Administrator Ralph K. Davies.

The staff will advise and assist the Administrator and the Deputy Administrator in developing and maintaining a plan of organization through which the activities of PAW can be most effectively directed, co-ordinated, and controlled.

Fish comes to the Petroleum Administration from a similar position with the War Production Board.

He is on leave of absence from the Standard Oil Company of California, with which he has been associated in organizational work for more than 20 years. A native of San Francisco, he is 43 years old and makes his home at Palo Alto, California.

Fish participated recently in a survey of the overall organization and management plans of 30 of the leading industrial concerns of the country and is co-author of the book "Top-Management Organization and Control" in which the principal findings of that survey are embodied.



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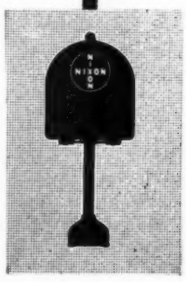

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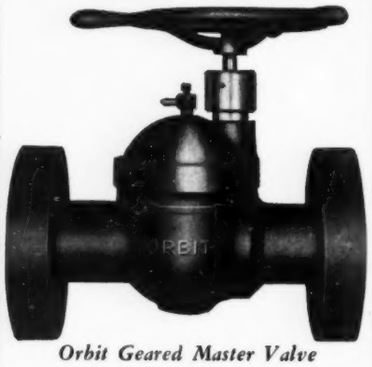

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Running Tour

WITH MEN IN THE INDUSTRY

W. A. STEELE has been appointed general superintendent of the Buffalo Works of the Wickwire Spencer Steel Company, succeeding FRED JOHNSON, who is retiring from active service after more than 20 years with Wickwire at its Buffalo plant.

EARL L. YOUNG, vice-president in charge of production for Laminated Shim Company, Inc., Blenbrook, Connecticut, has retired. Young has been with the company 22 years.

JEROME J. O'BRIEN has resigned as chief geologist of the Sunset Oil Company of California and is operating as a consulting geologist with offices in the Lane Mortgage Building, Los Angeles. For the last five months he has been in Canada preparing geological and valuation reports on the properties of France Oils, Ltd., and its subsidiary companies in the provinces of Alberta and Saskatchewan.

MR. and MRS. FRANK CHAMPION are celebrating the arrival of a daughter, FRANCES VIRGINIA, at Los Angeles on March 28. Champion is vice-president and general manager of Byron Jackson Company.

JAMES H. WITHERS has joined F. J. Hearty & Company, Los Angeles and San Francisco manufacturers' representatives, as a partner. Withers was for a number of years associated with the Petroleum Equipment Company of Los Angeles. The F. J. Hearty organization has been the California representative for The Edward Valve and Manufacturing Company, Inc., for nearly 25 years.

LUCIEN F. CRAIG has been appointed assistant director of the division of petroleum supply, it has been announced by Deputy Petroleum Administrator for War Ralph K. Davies. He has had 26 years' experience in the oil business, having been with Gulf Oil Corporation at Pittsburgh, Pennsylvania, before joining the agency.

P. H. CURRY, chairman of the board of the South Penn Oil Company, Pittsburgh, Pennsylvania, has resigned from that position and been succeeded by OTIS O. COLE, chief engineer and geologist.

FRED A. JESSER of Charleston, West Virginia, who has been assistant treasurer of the United Fuel Gas Company and associate companies of the Charleston Group of Columbia Gas and Electric Corporation, since 1929, has been elected treasurer of those companies to succeed W. J. HIGHTOWER. Hightower retains the office of vice-president, to which he was recently elected.

B. H. QUACKENBUSH has been named assistant sales manager of Foote Bros. Gear and Machine Corporation, Chicago, Illinois. In his new capacity he will continue to handle contract sales and, in addition, will supervise the activities of the priority department and the activities of the sales department under the Office of Price Administration on Price Regulations.

LAWRENCE VANDER LECK, one of the West Coast's outstanding independent oil producers, has been appointed Director of Production for District 5 of the Petroleum Administration for War. He succeeds in this post COMMANDER W. H. OSGOOD, who has been called to active duty by the United States Navy.

H. C. SMITH has been made farm boss of the Bluford, Illinois, district of the Lario Oil and Gas Company.

PHILLIP M. ROBINSON has resigned as assistant director of refining in the Petroleum Administration for War, effective March 31. Robinson resigned because of his health and plans to spend several weeks resting at his home in Detroit, Texas. Not until after he has fully regained his health does he contemplate making plans for the future.

M. E. FANNON, who has been executive assistant to J. R. MANION, vice-president and general manager in Tulsa, has been elected vice-president of the Pipe Line Department, Sinclair Refining Company. He will move his headquarters to Independence, Kansas. R. C. BEARDEN will assume his place in Tulsa.

H. L. MOORE, division geologist for The Atlantic Refining Company, has resigned to accept a position as manager of the exploration department of J. E. Crosbie, Inc., Tulsa, Oklahoma. He is succeeded at Atlantic by W. H. BUTT, his former assistant.

LIEUTENANT LAWRENCE SUCCOP, who was Texas-Louisiana-Oklahoma manager for American Roller Bearing Company with headquarters at Houston until he enlisted in the Army Air Force two years ago, is mentioned in recent newspaper dispatches as being one of the flyers to participate in an air battle over Wau Field, New Guinea, in which 26 Japanese planes were definitely destroyed and 15 others thought to have been shot down. The battle is described as being "one of the bitterest defeats that Japan has suffered at the hands of the American Air Force." C. F. SUCCOP, president of the American Roller Bearing Company, Pittsburgh, Pennsylvania, is the father of Lieutenant Succop.

GROVER D. MOTHERWELL has been appointed manager of the Minneapolis district of The B. F. Goodrich Company, it is announced by JAMES J. NEWMAN, vice-president. Motherwell succeeds ARTHUR J. MARTIN, who died recently.

FRANK E. HOLSTEN, executive vice-president of the Chalmette Refining Company, New Orleans, Louisiana, has been elected president of the Gulf Coast Refiners Association, succeeding D. W. HOVEY.

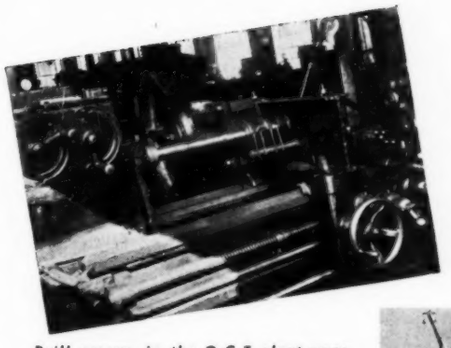
S. ROSS CARR, formerly deputy supervisor at Midland, Texas, for the Texas Railroad Commission, has resigned to associate himself with Adams and Bradley, independent operators of Midland.

MEYER DUBROW, who has been district engineer at Forsan, Texas, for the Continental Oil Company, is now division engineer with headquarters at Fort Worth.

PAUL L. MCGEE, petroleum engineer in the Galveston Bay district, Texas, for Humble Oil and Refining Company, has been transferred to the Conroe district. LOUIS F. BONNER has been transferred from the Goose Creek district to the Galveston Bay district.

ED M. DONS, chief engineer, has been promoted to assistant general superintendent of the West Tulsa refinery of the Mid-Continent Petroleum Corporation. N. B. YORK becomes process superintendent of the lubricating oil department.

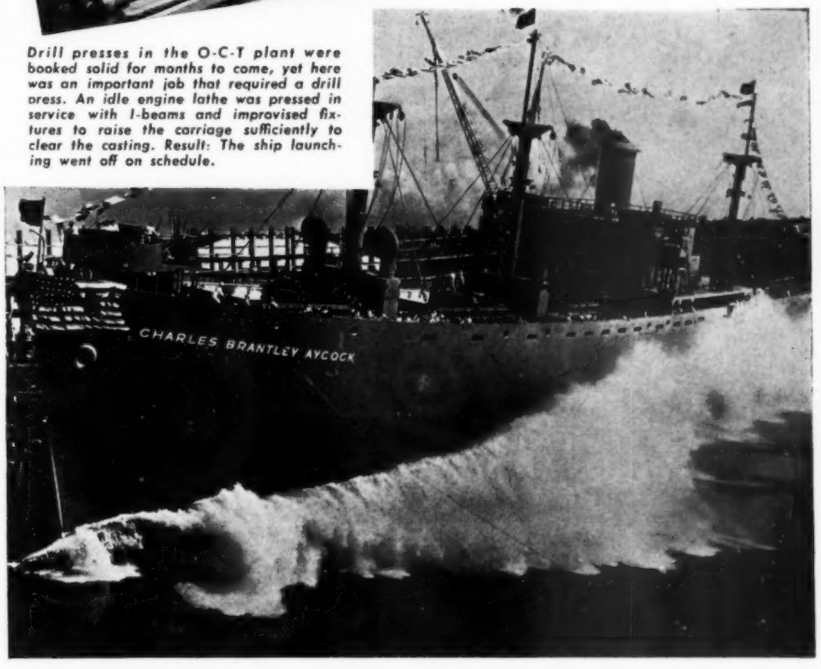
P. T. THIBODAUX, assistant manager of the oil pipe line department, has been promoted to manager, D. W. HARRIS, vice-president and general manager of the Arkansas Natural Gas companies, Shreveport, Louisiana, has announced. Thibodaux succeeds GORDON L. GANO, who is now associated with Cities Service Refining Corporation.



Plus or Minus

NOTHING!

Drill presses in the O-C-T plant were booked solid for months to come, yet here was an important job that required a drill press. An idle engine lathe was pressed in service with I-beams and improvised fixtures to raise the carriage sufficiently to clear the casting. Result: The ship launching went off on schedule.



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LAUGH WITH BARNEY

A male nurse in a mental hospital noticed a patient with his ear close to the wall, listening intently. The patient help up a finger as a warning for him to be very quiet; then beckoned him over and said: "You listen here."

The nurse put his ear to the wall and listened for some time, then turned to the patient and said: "I can't hear anything."

"No," said the patient, "and it's been like that all day."

* * *

Dizzy Lizzie says she read that on account of the war emergency the gals will have to wear the same things in brassieres for the duration.

* * *

"Why are you wearing the whistle tonight, daughter?"

"I have a date with a basketball player."

* * *

A draftee, called up for examination, claimed exemption on the ground of poor eyesight—and brought his wife along as evidence.

* * *

A WAAC asked the Commanding Officer: "Where do I eat?"

He answered: "You mess with the men."

She: "I know that, but where do I eat?"

* * *

Two Negro soldiers were on a transport going overseas. Standing on the deck they gazed out across the vast expanse of water.

That's the mos' water I've eber seen in all my life," said one. "Did yo' eber see so much water?"

Said his companion: "Yo' ain't seen nothin' yet. That's jus' the top ob it."

* * *

Mrs. Housewife barged into the grocery store and briskly asked: "Remember that cheese you sold me yesterday?"

Grocer: "Yes, madam."

Mrs. Housewife: "Did you say it was imported or deported from Switzerland?"

* * *

"Say, sister, do you know why girls walk home?"

Girl: No.

Boy: That's fine. Let's go for a spin.

* * *

He: Since I met you I can't eat, I can't sleep, I can't drink.

She (shyly): Why not?

He: I'm broke.

* * *

He: I'm a bank examiner.

She: Well, I'm no bank.

Sue: What's the age limit for sailors?

Liz: A sailor at any age is the limit, dearie.

* * *

A salesman who had spent several years calling upon purchasing agents found himself out of a job and joined the police force. Later a P. A. asked him how he liked it.

He replied: "Well, the pay isn't so good, but the thing I like about it is that the customer is always wrong."

* * *

Judge: You maintain that you threw your wife out of the third story window through forgetfulness?

Prisoner: Yes, we used to live on the ground floor, and I'd clean forgotten we'd moved.

* * *

Impression

She was young, fair and pretty,
She's a girl I'll never forget,
We were in a pullman sleeper
When, by accident, we met.

Yes, I always shall remember well
The girl and time, and place;
I was coming from an upper berth
And stepped upon her face.

* * *

Tact

The new secretary was on the carpet.

"Miss Jones," said the boss, "I may say that you're a very attractive girl."

"Really!" said the typist, blushing.

"You dress well; your voice is well modulated; your deportment is also beyond reproach."

"You really mustn't pay me so many compliments," she protested.

"Oh, that's all right! I only wanted to put you in a cheerful frame of mind before taking up the matter of punctuation and spelling."

* * *

A Tennessee hillbilly had been calling on his girl for almost a year, when pappy finally cornered him one night and asked:

"You been seeing Nelly for nigh onto a year. What are your intentions—honorable or dishonorable?"

The hillbilly's eyes sparkled: "You mean I got a choice?"

* * *

Dimples: They claim that when women adopted shorter skirts it reduced the number of street car accidents fifty percent.

Bill: Wouldn't it be fine if such accidents could be prevented altogether?

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT NO. 70

A VALUABLE and regular feature of *The Petroleum Engineer,* begun six years ago, the Continuous Tables were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer.* Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

To readers of *The Petroleum Engineer,* who are only now becoming interested in the Continuous Tables, it should be pointed out that each table is assigned a filing or index number that conforms with the Dewey Decimal System of classification as modified and extended for the petroleum and related industries by L. C. Uren, professor of Petroleum Engineering at the University of California. This complete index has been published in earlier installments of the tables and is now available in booklet form at a cost of 50 cents per copy from *The Petroleum Engineer,* P. O. Box 1589, Dallas, Texas. Complete sets of the tables from the first installment to the present are also available in conjunction with subscriptions.

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Hyatt Bearings Division, General Motors Sales Corporation	(sheet 1)	104	Aug.	P 532.911.
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 5)	74	July	P 622.001.
Hyatt Bearings Division, General Motors Sales Corporation		134	Sept.	P 615.222. P 622.24
Hyatt Bearings Division, General Motors Sales Corporation		154	Oct.	P 683.322.
Hyatt Bearings Division, General Motors Sales Corporation	(sheet 22)	144	Nov.	P 683.32
Hyatt Bearings Division, General Motors Sales Corporation		130	Dec.	P 622.1
Hyatt Bearings Division, General Motors Sales Corporation		138	Jan.	P 683.327.
Hyatt Bearings Division, General Motors Sales Corporation		132	Feb.	P 625.7
Hyatt Bearings Division, General Motors Sales Corporation		210	Mar.	P 615.211.0
Hyatt Bearings Division, General Motor Sales Corporation		152	Apr.	P 530.101.
Jones & Laughlin Steel Corporation	(sheet 23)	126	Dec.	P 683.32
Jones & Laughlin Steel Corporation		130	Feb.	P 683.330.
Kellogg, M. W., Company, The		154	Apr.	P 771.214.725.
LeRoi Company		108	Aug.	P 425.218.43
LeRoi Company		158	Oct.	P 514.541.
LeRoi Company		142	Nov.	P 516.922.005.
Linde Air Products Company, The		124	Dec.	P 622.4
Maxim Silencer Company	(sheet 26)	214	Mar.	P 683.32
Page Steel & Wire Division of American Chain and Cable Co., Inc.	(sheet 25)	124	Feb.	P 683.32
Parsons Company, The	(sheet 3)	158	Apr.	P 615.211.0
Pritchard, J. F., and Company		126	Feb.	P 621.
Ridge Tool Company		162	Oct.	P 546.32
Ridge Tool Company	(sheet 2)	144	Jan.	P 590.6
Twin Disc Clutch Company	(sheet 2)	136	Nov.	P 670.
Twin Disc Clutch Company		128	Feb.	P 772.4
Universal Atlas Cement Corporation	(sheet 3)	130	Sept.	P 532.911.
Universal Atlas Cement Corporation		122	Dec.	P 425.215.
Vortox Manufacturing Company	(sheet 18)	72	July	P 683.32
Vortox Manufacturing Company		164	Oct.	P 683.32
Waukesha Motor Company		128	Sept.	P 615.3
Whitney Chain and Manufacturing Company		132	Sept.	P 621.11
Whitney Chain and Manufacturing Company		140	Nov.	P 615.211.
Whitney Chain and Manufacturing Company		146	Jan.	P 210.0 P 771.0
Whitney Chain and Manufacturing Company		150	Apr.	P 425.218.433.

MUD WEIGHTING TABLES

APPROXIMATE NUMBER OF 100-LB. SACKS OF BARYTES OR IRON OXIDE TO BE ADDED TO 100 BBL. OF MUD OF ANY WEIGHT IN ORDER TO INCREASE THE WEIGHT BY ANY DESIRED NUMBER OF POUNDS PER UNIT VOLUME

Lb. per gal.				Lb. per cu. ft.			
Final weight lb. per gal.	Sacks per lb. per gal. increase per 100 bbl. mud	Final weight lb. per gal.	Sacks per lb. per gal. increase per 100 bbl. mud	Final weight lb. per cu. ft.	Sacks per lb. per cu.ft. increase per 100 bbl. mud	Final weight lb. per cu. ft.	Sacks per lb. per cu.ft. increase per 100 bbl. mud
8.5	55.5	14.5	71.7	67.5	7.57	100.0	9.09
9.0	56.5	15.0	73.5	70.0	7.67	102.5	9.23
9.5	57.7	15.5	75.4	72.5	7.77	105.0	9.38
10.0	58.8	16.0	77.4	75.0	7.87	107.5	9.53
10.5	60.0	16.5	79.5	77.5	7.98	110.0	9.69
11.0	61.3	17.0	81.7	80.0	8.09	112.5	9.85
11.5	62.6	17.5	84.0	82.5	8.20	115.0	10.02
12.0	63.9	18.0	86.5	85.0	8.32	117.5	10.19
12.5	65.3	18.5	89.1	87.5	8.44	120.0	10.37
13.0	66.8	19.0	91.9	90.0	8.56	122.5	10.56
13.5	68.4	19.5	94.9	92.5	8.68	125.0	10.75
14.0	70.0	20.0	98.0	95.0	8.81	127.5	10.95
				97.5	8.95	130.0	11.16

Increase in volume of mud in barrels equals total 100-lb. sacks of barytes or iron oxide added multiplied by 0.068. One hundred (100) sacks of barytes or iron oxide occupies volume of 6.8 bbl.

Example of use of table: How many sacks of barytes or iron oxide will be required to increase the weight of 500 bbl. of 11-lb.-per-gal. mud to 12.5 lb. per gal.?

Solution: Since the increase will be 1.5 lb., and opposite 12.5 (Final weight) is read 65.3, then 1.5×65.3 or 98 sacks will be required for each 100 bbl. Since there are 500 bbl., then 5×98 or approximately 490 sacks will be required altogether. This will increase the volume of the original mud 4.90×6.8 or by about 33 bbl.

PERCENT SOLIDS—WEIGHT—YIELD RELATIONSHIP OF CLAY—WATER DRILLING MUDS

Percent clay by weight	Weight			Yield		Percent clay by weight	Weight			Yield	
	Lb. per gal.	Lb. per cu. ft.	*A.P.I. density	Bbl. mud per ton of of clay	Tons clay per 100 bbl. of mud		Lb. per gal.	Lb. per cu. ft.	*A.P.I. density	Bbl. mud per ton of of clay	Tons clay per 100 bbl. of mud
1	8.38	62.69	43.54	567.58	0.176	21	9.53	71.30	49.51	23.77	4.207
2	8.43	63.07	43.80	282.08	0.355	22	9.60	71.79	49.86	22.53	4.439
3	8.48	63.46	44.07	186.91	0.535	23	9.66	72.29	50.20	21.41	4.671
4	8.54	63.85	44.34	139.33	0.718	24	9.73	72.80	50.55	20.37	4.909
5	8.59	64.24	44.61	110.78	0.903	25	9.80	73.31	50.91	19.42	5.149
6	8.64	64.64	44.89	91.75	1.090	26	9.87	73.83	51.27	18.54	5.394
7	8.70	65.05	45.17	78.15	1.280	27	9.94	74.36	51.64	17.73	5.640
8	8.75	65.46	45.46	67.96	1.472	28	10.01	74.90	52.01	16.97	5.893
9	8.81	65.87	45.75	60.02	1.666	29	10.09	75.44	52.39	16.27	6.146
10	8.86	66.29	46.04	53.68	1.863	30	10.16	76.00	52.77	15.61	6.406
11	8.92	66.72	46.33	48.49	2.062	31	10.23	76.56	53.16	15.00	6.667
12	8.98	67.15	46.63	44.16	2.264	32	10.31	77.12	53.56	14.42	6.935
13	9.04	67.59	46.93	40.50	2.469	33	10.39	77.70	53.96	13.88	7.205
14	9.09	68.03	47.24	37.37	2.676	34	10.47	78.29	54.37	13.37	7.479
15	9.15	68.48	47.55	34.65	2.886	35	10.54	78.88	54.78	12.89	7.758
16	9.22	68.93	47.87	32.27	3.099	36	10.63	79.48	55.20	12.44	8.039
17	9.28	69.39	48.19	30.17	3.315	37	10.71	80.10	55.62	12.01	8.326
18	9.34	69.86	48.51	28.30	3.534	38	10.79	80.72	56.06	11.61	8.616
19	9.40	70.33	48.84	26.63	3.755	39	10.88	81.35	56.49	11.22	8.912
20	9.47	70.81	49.18	25.13	3.979	40	10.96	81.99	56.94	10.86	9.212

Note: For practical purposes, a specific gravity of 2.5 has been assumed for all clays.

*Pressure at the bottom of a well due to the weight of fluid column in the well, in lb. per sq. in. per 100 ft. of column.

Data for these tables supplied by Baroid Sales Division, National Lead Company.

ANNOUNCING
A New "Drive-Connection"

between
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CHAIN & MFG. CO.
HARTFORD, CONN.

and
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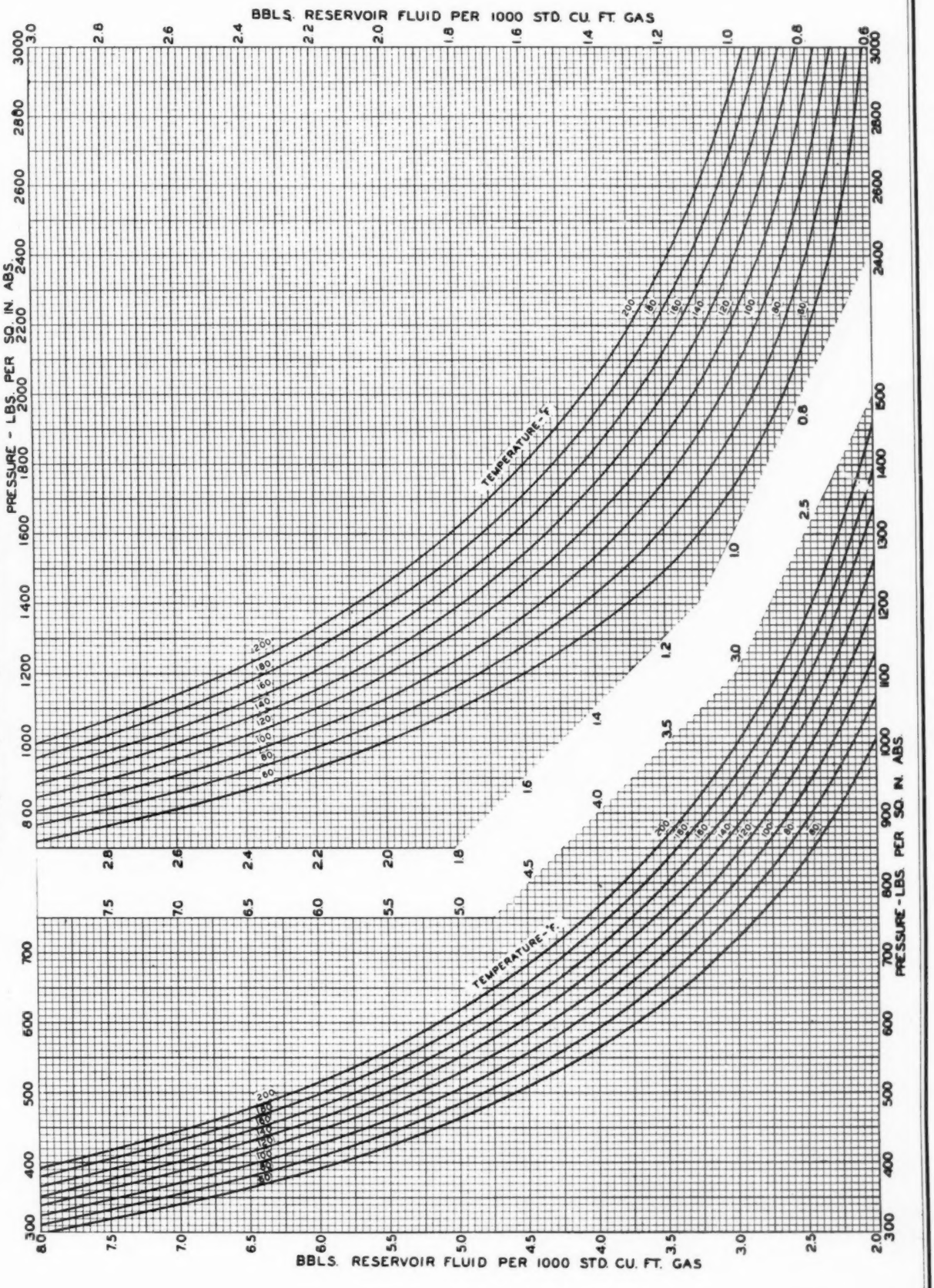
The CONTINENTAL SUPPLY COMPANY is now exclusive distributor of Whitney Roller Chains throughout the oil fields. So oilfield operators now get . . . "in one package" . . . the double advantage of Continental's top-flight supply and engineering service . . . and the top performance of Whitney Chain Drives that are designed and built to deliver full power to the job under today's non-stop conditions.

RESERVOIR VOLUME OCCUPIED BY EXCESS GAS

—*Chart by George Granger Brown, University of Michigan.*



★ ★ ★ ★ ★ ★

You can't spell VICTORY with "T" an absent "T"

JOHN F. NOON
Hyatt Roller Bearing
Precision Grinding Dept.

John Noon points with pride to the slogan he originally entered in a Hyatt employe's contest and which has since swept the country like a whirlwind.

So many requests have come in for permission to use the above contest-winning slogan . . . originated by John Noon, a Hyatt worker . . . that we have had extra posters printed in color for free distribution among other war production plants.

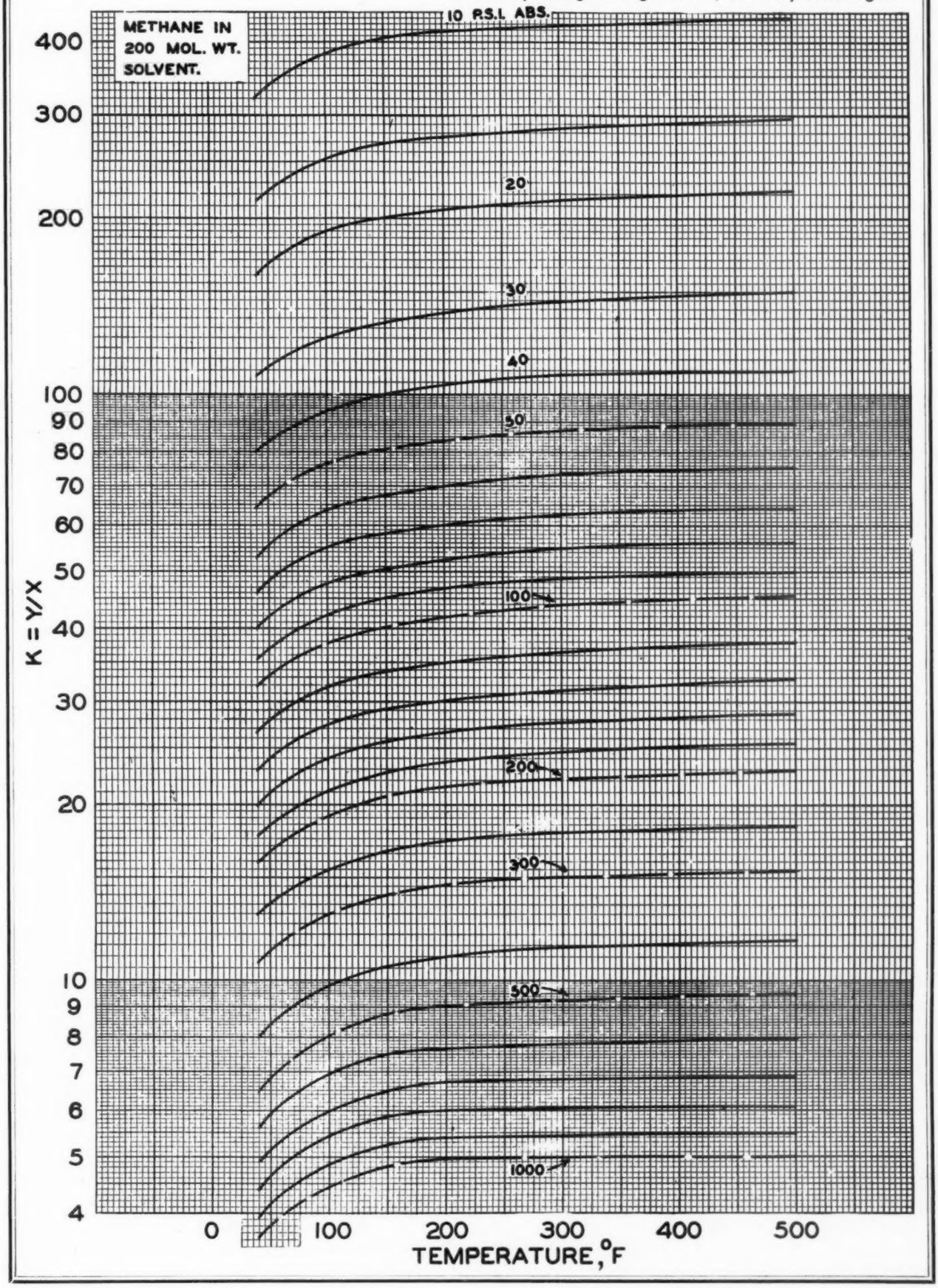
These are now available . . . singly or in reasonable quantity . . . in either 19x25-inch or 8½x11-inch sizes.

Please make your request on company letterhead and be sure to mention size desired.

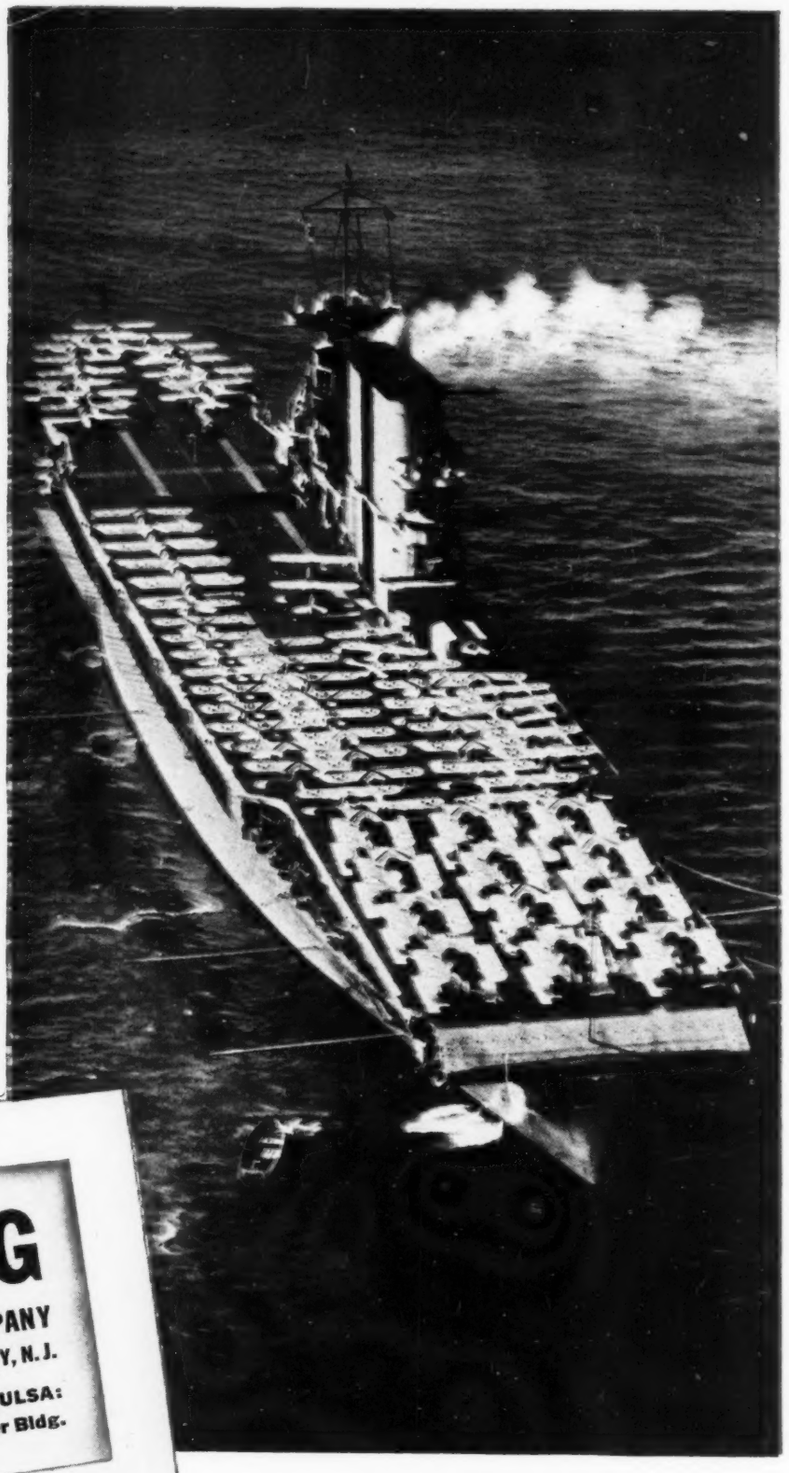
Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

VAPORIZATION EQUILIBRIUM CONSTANTS FOR METHANE

—*Chart by George Granger Brown, University of Michigan.*



"All our planes returned safely"



What a thrilling message to send out.

KELLOGG is privileged at this time of national crisis to build plants producing aviation gasoline which makes such messages possible.

KELLOGG

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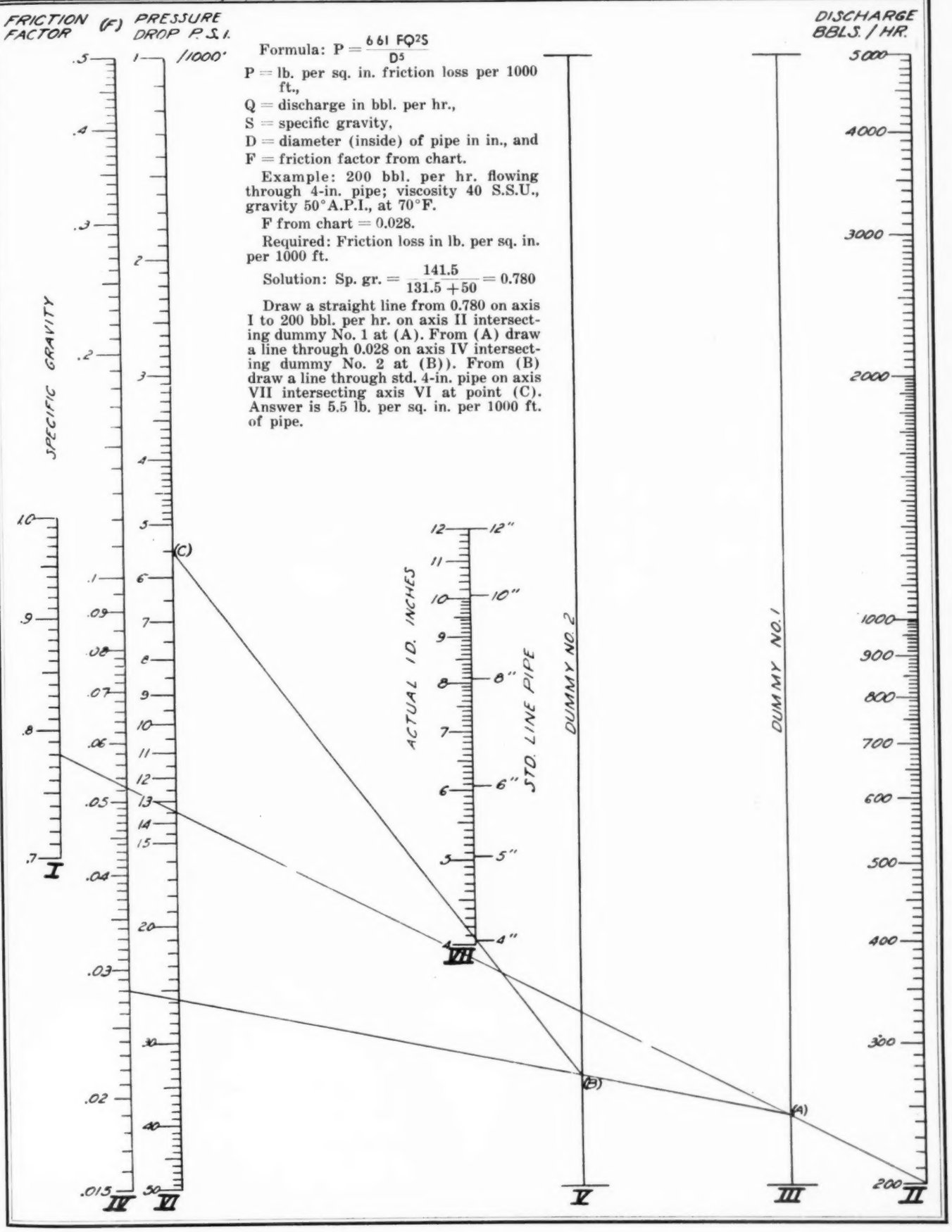
CATALYTIC PROCESSES for Cracking, Hydroforming, Reforming, Dehydrogenation, Alkylation, Desulphurization
GASOLINE PRODUCTS COMPANY, INC....Pyrolytic Cracking • THE POLYMERIZATION PROCESS CORPORATION...Thermal and Catalytic Polymerization
JUIK Processes . . . for Lubricating Oil Refining with Propane and Phenol • Deasphalting • Dewaxing • Solvent Extraction and Acid Treating Plants

CHART FOR SOLUTION OF FORMULA $P = \frac{6.61\ FQ^2S}{D^5}$ FOR FLOW OF CRUDE OIL IN PIPE LINES



Formula: $P = \frac{6.61\ FQ^2S}{D^5}$

P = lb. per sq. in. friction loss per 1000 ft.,

Q = discharge in bbl. per hr.,

S = specific gravity,

D = diameter (inside) of pipe in in., and

F = friction factor from chart.

Example: 200 bbl. per hr. flowing through 4-in. pipe; viscosity 40 S.S.U., gravity 50°A.P.I., at 70°F.

F from chart = 0.028.

Required: Friction loss in lb. per sq. in. per 1000 ft.

Solution: Sp. gr. $= \frac{141.5}{131.5 + 50} = 0.780$

Draw a straight line from 0.780 on axis I to 200 bbl. per hr. on axis II intersecting dummy No. 1 at (A). From (A) draw a line through 0.028 on axis IV intersecting dummy No. 2 at (B)). From (B) draw a line through std. 4-in. pipe on axis VII intersecting axis VI at point (C). Answer is 5.5 lb. per sq. in. per 1000 ft. of pipe.

BACK UP YOUR MEN IN THE FIELD

● More than a score of years devoted to close work in the field and with progressive manufacturers of oil field rigs have given DIAMOND Chain engineers experience for which there is no substitute.

Oil field men have come to respect the recommendations made by Diamond engineers—and long years of everyday performance have proven that DIAMOND Roller Chains have the durability, reserve power, long life, high efficiency that reduce operating costs, cut maintenance and delays—insure maximum results. Your men in the field can do better with DIAMOND-equipped rigs.

Good engineering on the part of rig builders is responsible for the wide usage of DIAMOND Chains—good judgment suggests their use for replacements, too. DIAMOND CHAIN & MFG. CO., 441 Kentucky Ave., Indianapolis, Indiana. Tulsa Office: 2238 Terwilleger Blvd.

DIAMOND
ROLLER CHAINS

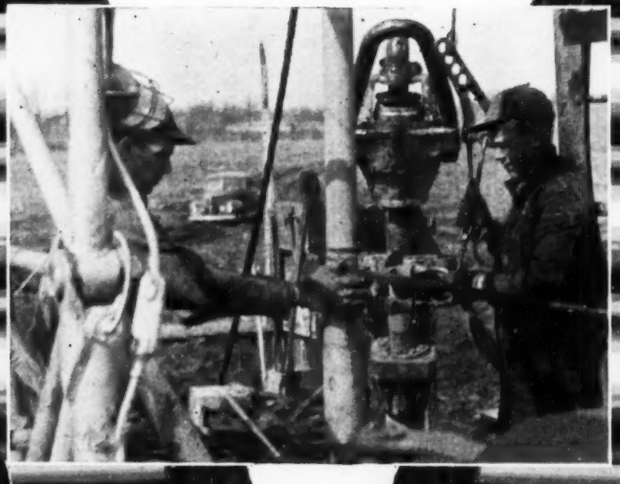
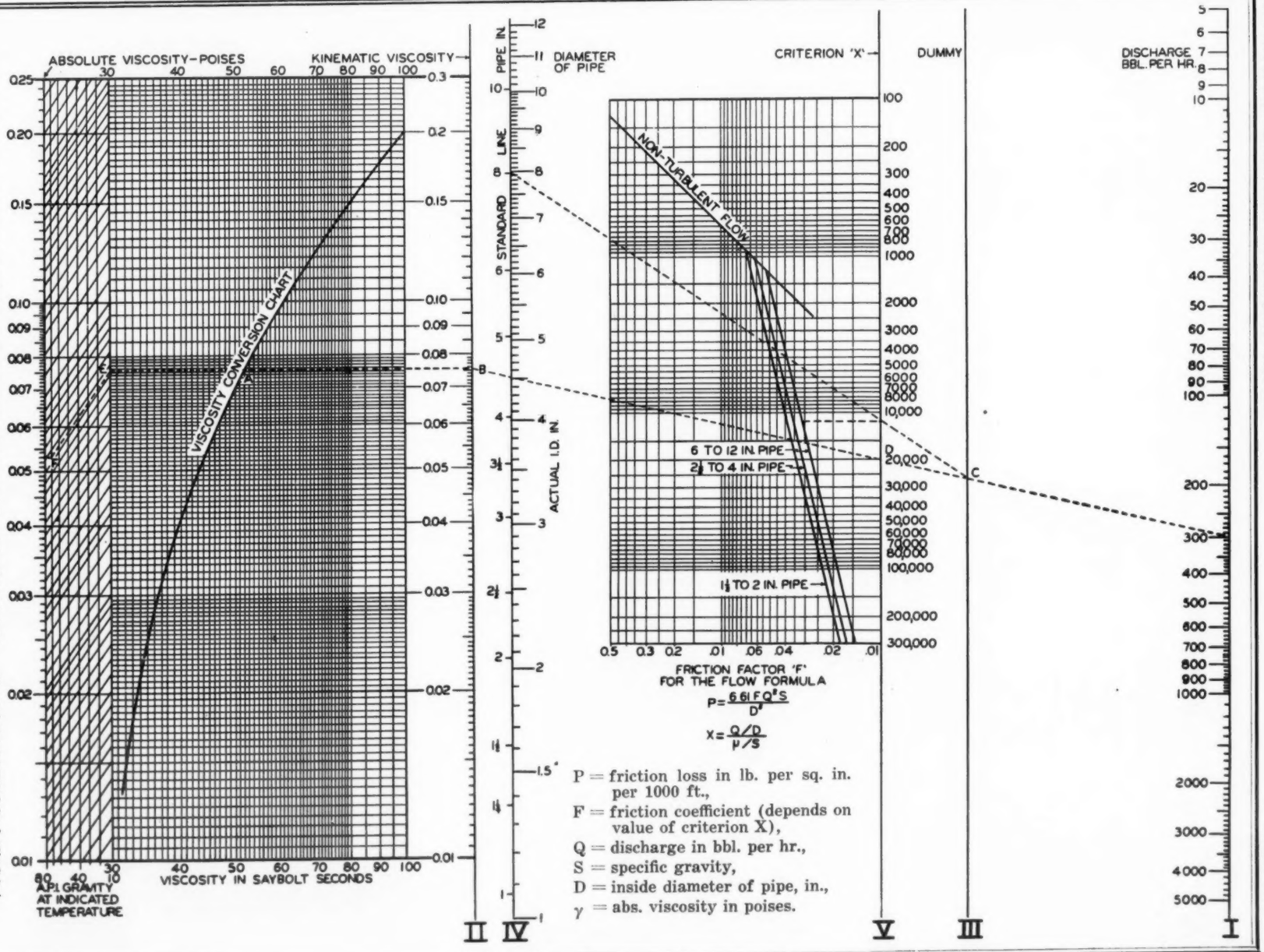


CHART FOR DETERMINING THE VALUE OF "F" FOR USE IN THE FORMULA $P = \frac{6.61\,FQ^2S}{D^5}$

EXAMPLE: 300 bbl. per hr. flowing through Std. 8-in. pipe; viscosity 52 S.S.U. specific gravity 70° A.P.I. at 70°F. Find the friction factor F.

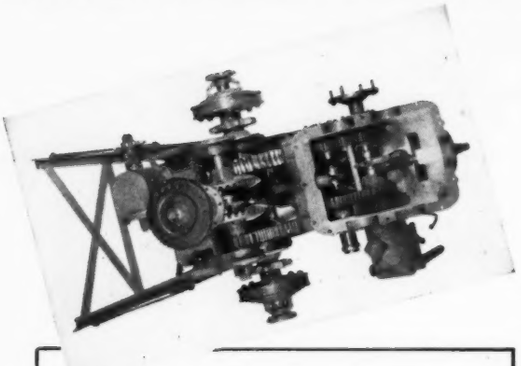
Solution: On the viscosity conversion chart draw a vertical line from 52 S.S.U. to point A where it intersects the conversion curve. From A draw a line horizontal to Axis II which it intersects at point B. From B draw a straight line to 300 bbl. per day on Axis I. This line intersects Dummy Axis III at C. From C draw a straight line to 8-in. Std. line pipe on Axis IV. This line intersects Axis V at D. The reading at D is the Criterion X. F can now be determined by use of the chart attached to Axis V. Using the line 6 to 12 in. pipe on the chart and the value of X determined, F is found as 0.031. Under the conditions given it can be seen that turbulent flow will result.

If it is desired to know the absolute viscosity in poises, draw a horizontal line from A to the 10° A.P.I. gravity line, point E. From E draw the line parallel to the diagonal lines to F where it intersects the gravity (70° A.P.I.). From F draw a horizontal line to the left of the chart where the abs. viscosity can be read directly as 0.53.



P = friction loss in lb. per sq. in. per 1000 ft.,
F = friction coefficient (depends on value of criterion X),
Q = discharge in bbl. per hr.,
S = specific gravity,
D = inside diameter of pipe, in.,
γ = abs. viscosity in poises.

PARSONS



Trouble-free operation will continue indefinitely for you as long as your machine is oiled and greased regularly. Don't let dust-wear scrap a vital war machine, and guard against friction, too, by having your Trencher lubricated today. Give your Parsons' Trencher a regular routine checkup, and you'll be thankful for the continuous severe service it will give you.

TRENCHERS Slice Paths for Pipe Line Terminals

Pipe lines, especially those being placed now, must be laid out to join terminals with the least possible distance between. This means that engineers can't be too much concerned over terrain or ground formations. That's why they depend on Parsons Trenchers to dig the trenches. Parsons Trenchers are designed for all kinds of service and thrive on the tough jobs. They handle the wide deep ditches as economically and efficiently as the easier shallow trenches. Fully enclosed gearing and ample power make Parsons Trenchers handle more work and last longer. Save time and money on your pipe line trenching with a Parsons.

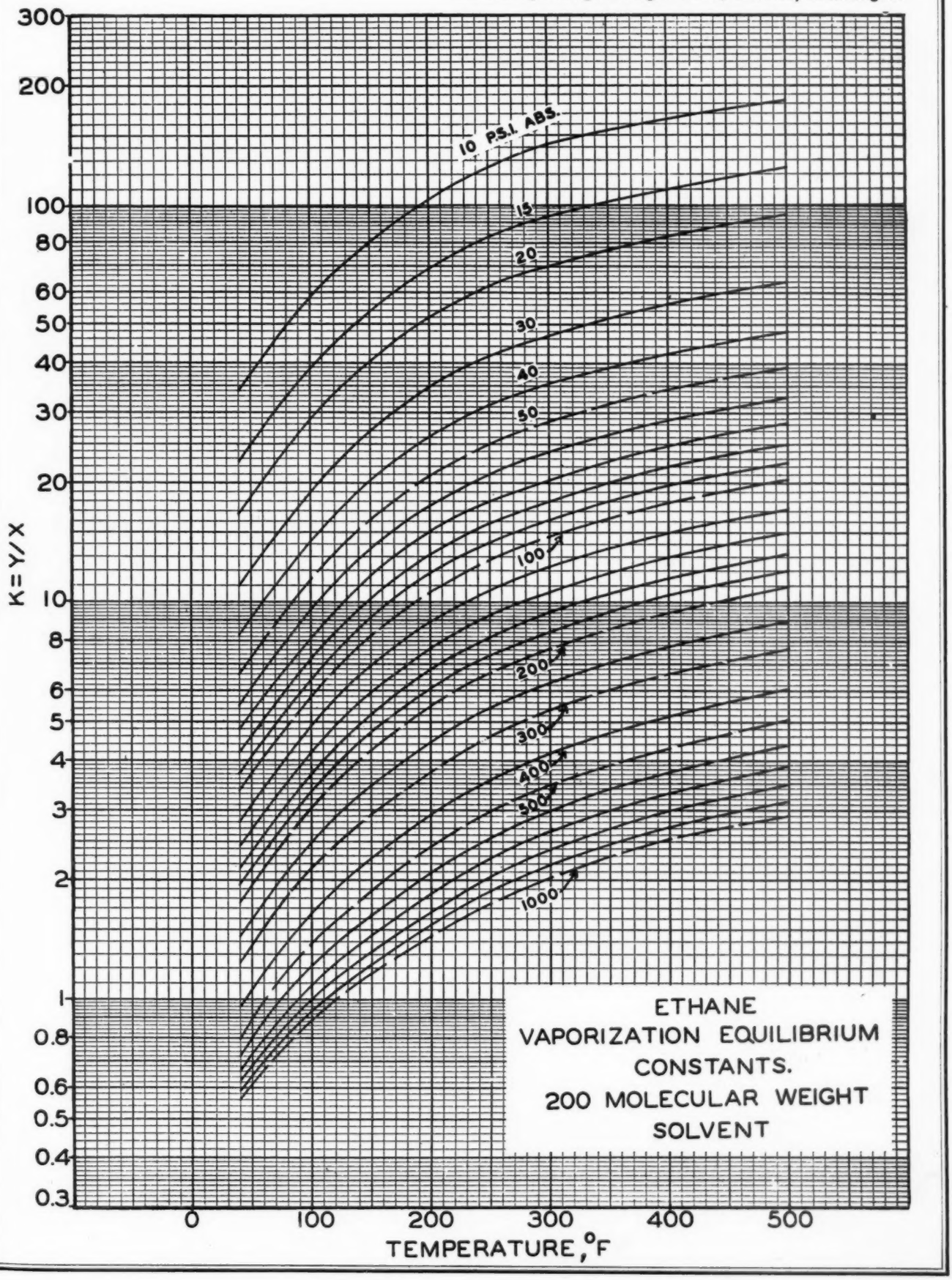
THE PARSONS COMPANY, NEWTON, IOWA

TRENCHING EQUIPMENT

PARSONS

VAPORIZATION EQUILIBRIUM CONSTANTS FOR ETHANE

—Chart by George Granger Brown, University of Michigan.



BROWN FINTUBE HEAT EXCHANGERS

Give extra capacity for any exchange between liquids and gases...or other materials having unequal heat transfer co-efficients

● Because Brown integrally bonded Fintubes, having the desired number and depth of fins, are used in effecting the heat transfer,—the primary and secondary tube surfaces of Brown Fintube Heat Exchangers can be proportioned to the transfer co-efficients of the materials being heated or cooled, thereby compensating for any deficiency in the heat transfer rate of one or another of the commodities.

This avoids the necessity of using hundreds, sometimes thousands of feet of bare tubing to satisfy the requirement of the commodity having lower heat transfer co-efficient. It permits a fewer number, or shorter, Brown Fintubes to be used for a given heat transfer service than if plain bare tubes were used . . . and results in smaller shells, less back pressure, less pressure drop, and many other important savings in manufacturing, shipping, installation and maintenance costs.

Brown Integrally Bonded Fintubes are used in all Brown Fintube Heat Exchangers—in exchangers made by most other manufacturers—and are available in a wide variety of sizes, and in mild carbon or special steels, for practically any heating or cooling requirement.

Six standard and many special types of Brown Fintube Heat Exchangers meet every requirement for effecting transfers between liquids and gases, or other commodities having unequal transfer co-efficients,—and provide the high thermal efficiency and trouble-free operation that only Brown resistance-welded integrally bonded Fintubes can give you.

More complete details, engineering assistance, estimates, and descriptive literature furnished gladly on request. Let us quote on your heat exchanger requirements.

THE BROWN FINTUBE CO.

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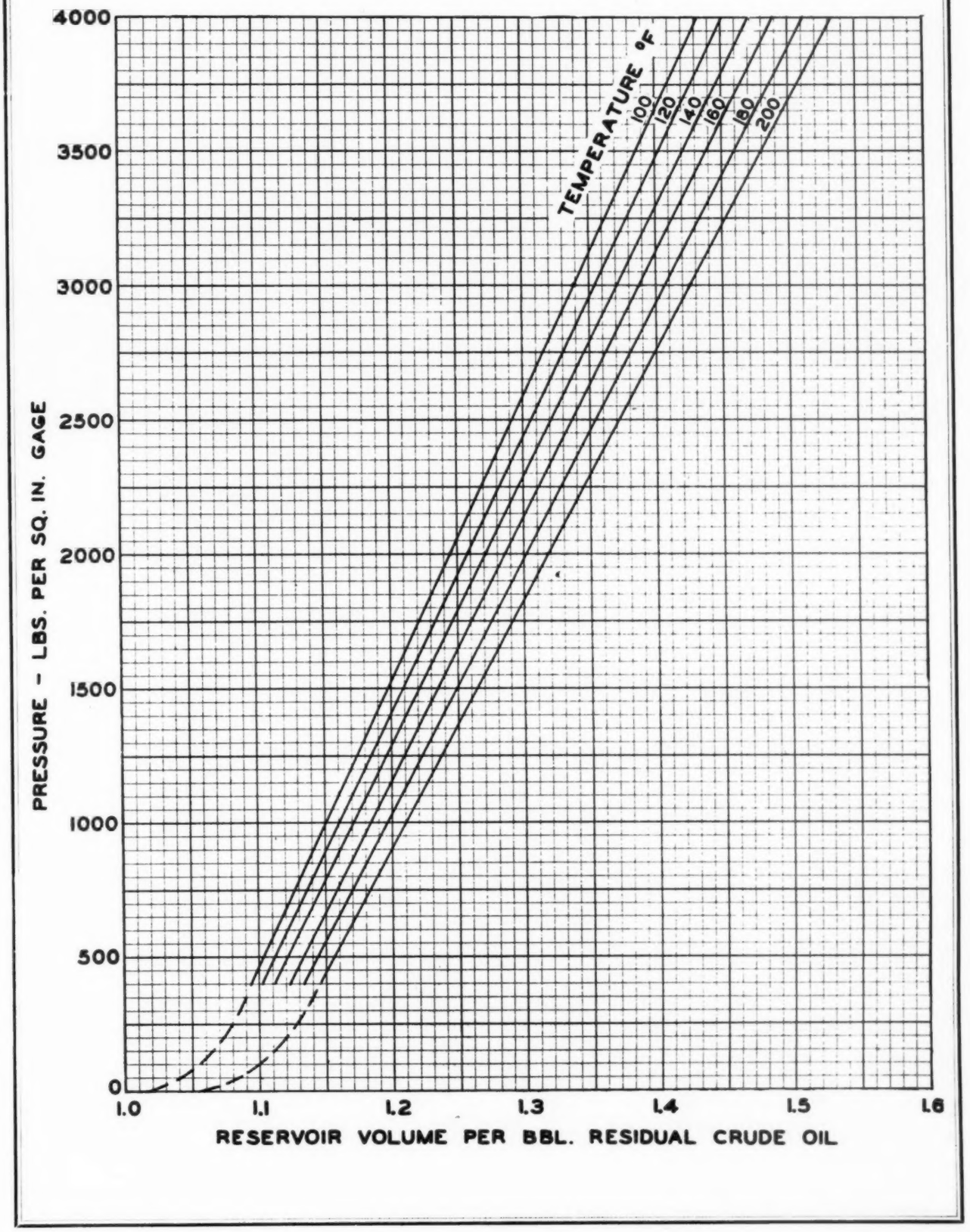
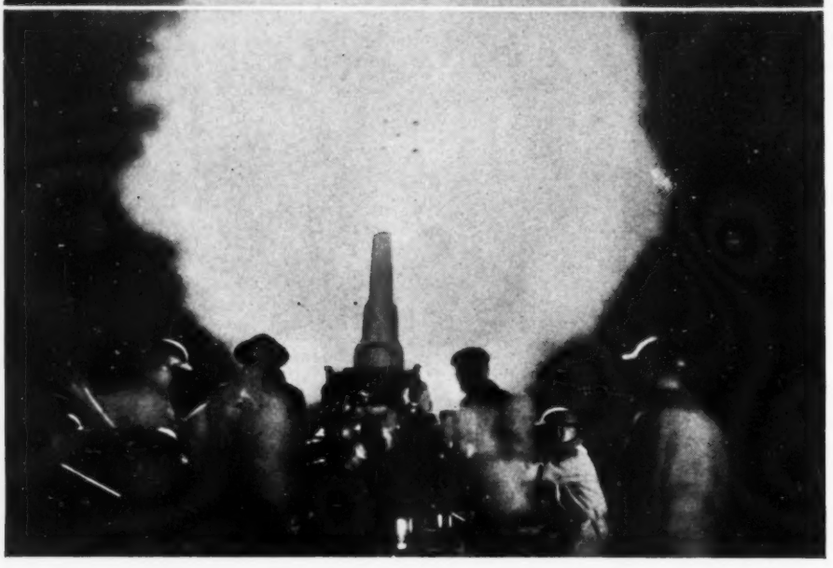
MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

RESERVOIR VOLUME OCCUPIED BY OIL AND DISSOLVED GAS

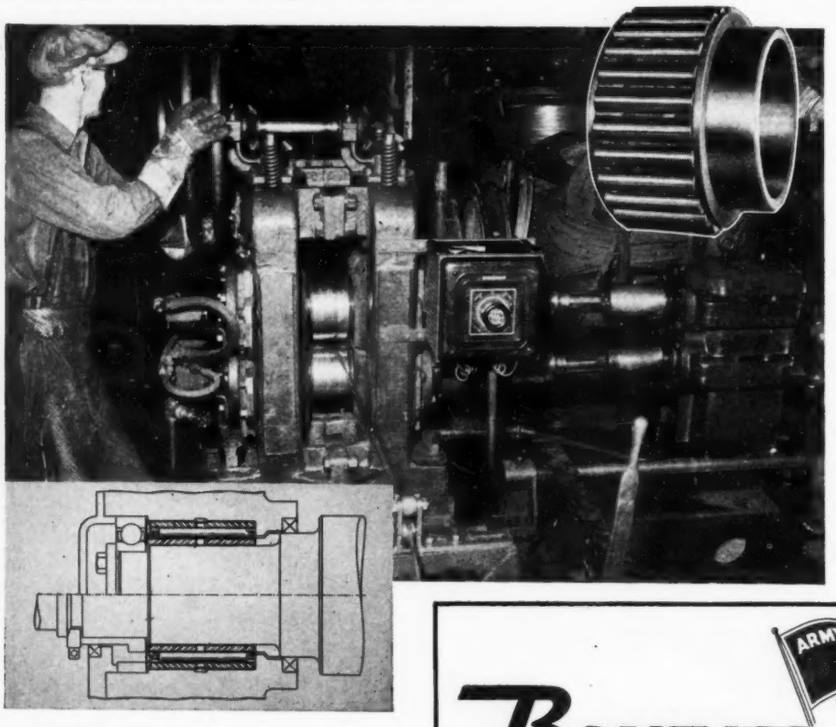
—Chart by George Granger Brown, University of Michigan.



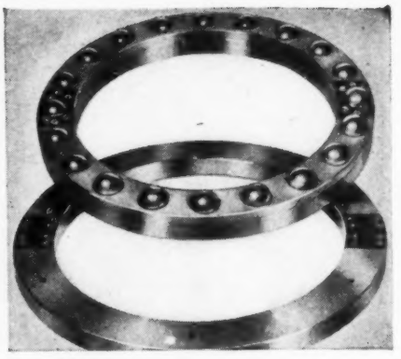
IN THE NEWS
WITH BANTAM BEARINGS



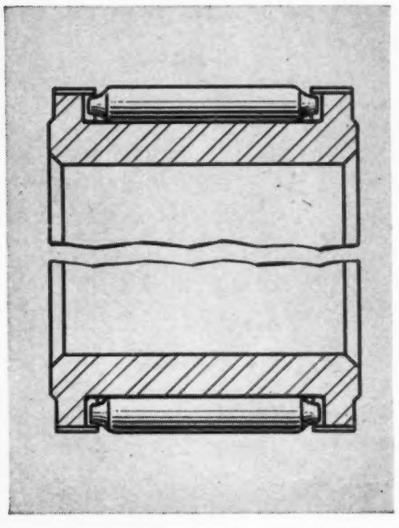
THE TARGET IS MILES ABOVE—yet these 3-inch anti-aircraft guns find their mark with deadly accuracy. The design of America's war equipment—and of the machines to produce it—presents new challenges to industry—and Bantam's skill in the design of special bearings is of great assistance in meeting these new tasks. To serve America's war needs, Bantam has built some of the largest anti-friction bearings ever constructed.



HIGH CAPACITY in a small space is provided by Bantam straight radial roller bearings in this 8-inch flattening mill built by Broden Construction Company, while Bantam Ball Bearings take the thrust load. The bearing arrangement, shown in cross-section view, permits compact design and ease of assembly.



SPLIT-RACE BEARINGS like this one, of the ball thrust type, 19½" I.D., 25" O.D., 3¾" thick, frequently facilitate the assembly of machines. This is typical of the many types of out-of-the-ordinary bearings that Bantam has produced for unusual requirements. Split-race bearings have also been designed and manufactured by Bantam in roller thrust and radial types.



MODIFIED QUILL BEARINGS are adaptable to special applications—retain the familiar advantages of the standard type. In the bearing shown, the rolls are retained to the inner race instead of the outer, as in the standard Quill Bearing. This construction is useful for cases where it is difficult to assemble the parts when the rollers are retained by the outer race.

BANTAM'S ENGINEERING EXPERIENCE covers the design and application of every major type of *standard* anti-friction bearing, as well as of a wide variety of special sizes and types. For advice on the selection of bearings that meet *your* requirements, TURN TO BANTAM.

ARMY E NAVY

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION · SOUTH BEND · INDIANA

SUBSIDIARY OF THE TORRINGTON COMPANY · TORRINGTON, CONN.

MACHINERY and EQUIPMENT

World's Largest Seamless Welding Elbow

NOW IN production at Tube Turns, Inc., Louisville, Kentucky, is a 30-in. seamless welding elbow to be used in sea-going drydocks for the United States Navy. These are the largest seamless elbows ever made, according to the manufacturer. Under

their own power these drydocks will follow the fleet to battle areas where they will facilitate below-the-waterline repairs on all fighting ships and battle fleet-servicing ships. "Wounded" battleships, carriers, cruisers, submarines, destroyers, transports, supply ships, and tankers will be saved that otherwise would sink before they could get back to a base.

A floating drydock is essentially a huge, hollow platform that partly submerges, by letting water inside, until the ship to be serviced is floated above it. Then it rises, by pumping out the water from its hollow interior until the ship is no longer afloat. Batteries of large pumps will pump the water out through the 30-in. welded pipe lines made with these huge elbows.

Lightweight Thyratron Tube

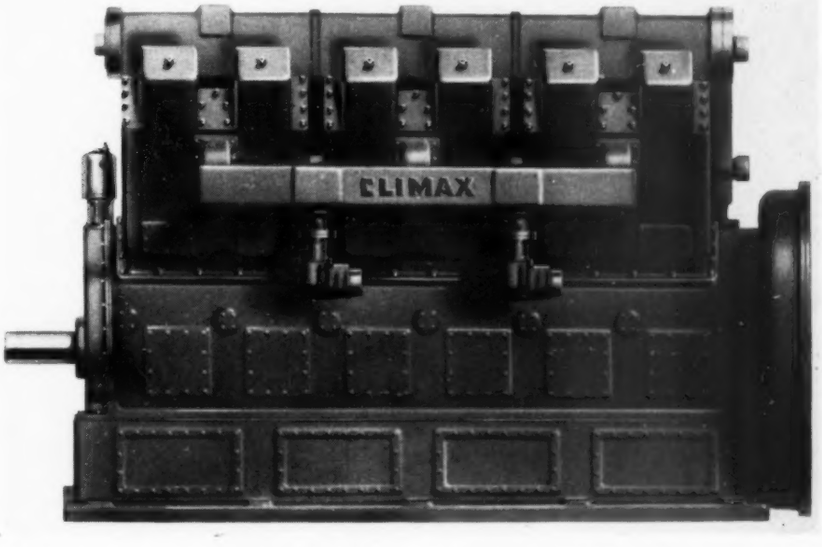
DESIGNED for applications where weight and space must be considered, a new thyratron tube with both a control and a shield grid for control applications, has been announced by the tube division of the General Electric Electronics Department, at Schenectady, New York. Designated as the GL-502, the new tube is a little more than 2½ in. long, weighs about 2 oz., is inert-gas-filled and of all-metal construction. Applications for the new tube will be found in industrial welding and any general control equipment.

"The control characteristic is practically independent of ambient temperature over a wide range," according to O. W. Pike, G-E engineer. "Since the grid current is low enough to permit the use of a high resistance in the grid circuit, the new thyratron has high sensitivity characteristics. The grid-anode capacitance is low enough so that the new tube is relatively unaffected by line-voltage surges. It has a maximum peak inverse anode voltage rating of 1300 volts, instantaneous current rating of 500 milliamperes, and an average current rating of 100 milliamperes. The cathode is quick heating and is rated at 6.3 volts, 0.6 amp."

Climax V-12 Blue Streak Engine

CLIMAX Engineering Company, Clinton, Iowa, announces the new V-12 Blue Streak Engine — the latest addition to the extensive line of the company's engines and engine-generator sets.

With a normal speed range of 600 to 1200 r.p.m. and a b. hp. of 435, the new V-12 meets today's demands for a high-speed engine that will mesh with modern power consuming machinery for rock or oil drilling, operating large pumps and compressors, driving mining and construction machinery and, with suitable generators, a low cost means of generating electric power, according to the manufacturer. For oil-field service the new Climax V-12 engine is used as a power unit for deepwell oil drilling, oil-well and pipe-line pumping, and for stationary power and construction service.



Dual ignition can be supplied in the following combinations: (1) Dual battery ignition, (2) dual magneto ignition, and (3) dual battery and magneto ignition.

Standard design features include wet cylinder sleeves, seven-bearing crankshaft, overhead valves, aluminum (5-ring) pistons, rifle drilled connecting rod and fuel change-over devices. When required, Climax will provide a complete range of accessory equipment such as starting devices, air cleaners, filters, radiators, heat exchangers, etc. All of these may be selected to meet the specific needs of the particular installation.

For more complete information — specifications, test data, recommended applications — write to Climax Engineering Company, Clinton, Iowa.

A NATURAL
for any job

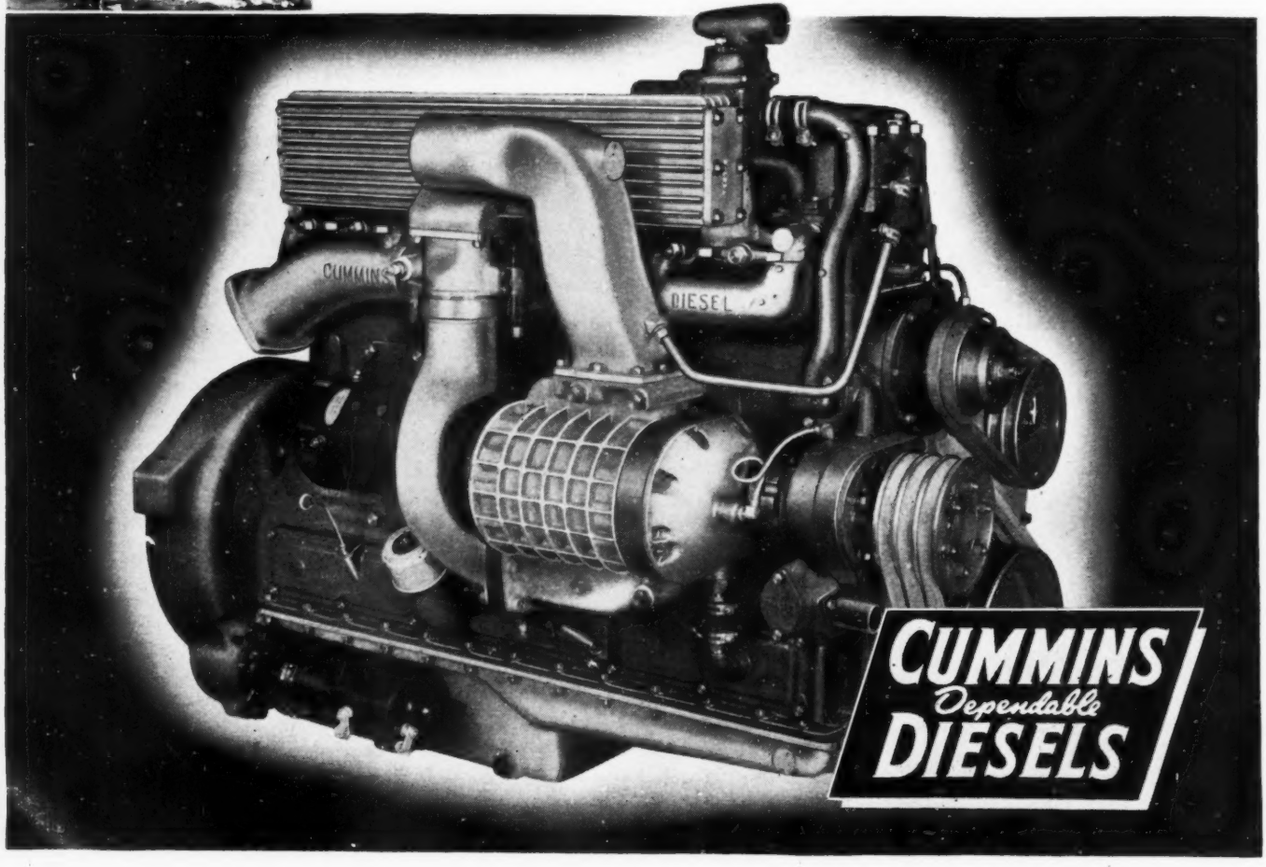
No matter what the service—heavy-duty trucking, construction, logging, oil well drilling, generating, marine power—Cummins Dependable Diesels are a *natural*. A *natural* because Cummins Dependable Diesels have proved their ready adaptability . . . their consistent, long-time dependability . . . their all-over economy, in the widest variety of applications . . . automotive . . . industrial . . . marine.

It is this record of proved performance in every heavy-duty service which explains the demand for Cummins Dependable Diesels for all types of National Defense work . . . that's why nine out of every ten Cummins Dependable Diesels are tagged for some preparedness job that demands power of unquestioned reliability. Cummins Engine Company, Columbus, Indiana.

MID-CONTINENT SUPPLY COMPANY • FORT WORTH, TEXAS

Distributors Mid-Continent Territory

Model HBS-600 (supercharged) Cummins Dependable Diesel. 200 hp. at 1800 rpm.



Vertical Hollow Shaft Explosion-Proof Motors

A NEW line of vertical hollow shaft explosion-proof motors is now offered by Fairbanks, Morse and Company, Chicago, Illinois, for operation in Underwriters' Class I Group D hazardous gas locations. These motors are de-

signed primarily for pumps handling large quantities of volatile materials such as high octane aviation gasoline.

Special equipment is required for the efficient handling of gasoline in fueling planes at each of our numerous air fields, as well as for transferring gasoline from tankers to storage locations at our various outposts throughout the world. Numerous applications are arising requiring motors designed to prevent explosions and fires and Fairbanks-Morse horizontal and vertical explosion-proof motors are designed to minimize this hazard.

Liquid Seal Vent Valve

THE Conser-Vent is a new liquid seal vent valve designed for installation on storage tanks. Its purpose is to minimize the evaporation loss of volatile petroleum products in storage, and at the same time protect the tank and its contents against the hazards associated with excessive pressure and vacuum. The Conser-Vent has no mechanical parts. Its principal operating units are (1) an oil seal that serves as a liquid "valve" and provides for all ordinary conditions; (2) a movable bell that automatically relieves extraordinary pressure conditions, and (3) two entrainment separators that entrap any oil particles that escaping gases may pick up and thus prevent depletion of the sealing liquid.

Normal "breathing" of the tank's contents causes the liquid seal to rise and fall in response to changing pressures. This principle equips the tank with a "breathing" apparatus that provides instant and constant relief without the loss of vapors.

When the withdrawal of gasoline or a drop in temperature causes a vacuum, air from the atmosphere enters the Conser-Vent, bubbles through the oil seal, relieving the vacuum and passes into the storage tank.

The Conser-Vent is designed and manufactured by the Conservation Equipment Corporation, 624 South Michigan Avenue, Chicago, Illinois. It is available in 3-, 6- and 10-in. sizes and operates on tanks up to the largest capacity.

Seamless Plastic Tubing

EXTRUDED Plastics, Inc., Norwalk, Connecticut, announce that "Tulox" TT seamless plastic tubing is now available in all diameters up to 2-in. O.D. Within the next few weeks the range will be increased to 2½-in. O.D., to meet requirements of war production.

Extruded from Tennessee Eastman cellulose acetate butyrate, this tubing is available from warehouse stocks throughout the country through Crane Company, Chicago, Illinois, and Julius Blum and Company, Inc., New York City.

4 POINTS

No. 1 Mechanically applied Primer.

Nos. 2, 3, 5 Mechanically agitated enamel coating.

No. 4 Bonded asbestos felt.

No. 6 80-lb. Imprinted Kraft Paper.

THE ECHO IS DIFFERENT *but* THE MEANING IS THE SAME

The excellent record of HILL-HUBBELL Steel Pipe Protection will echo through years of continuous money-saving performance.

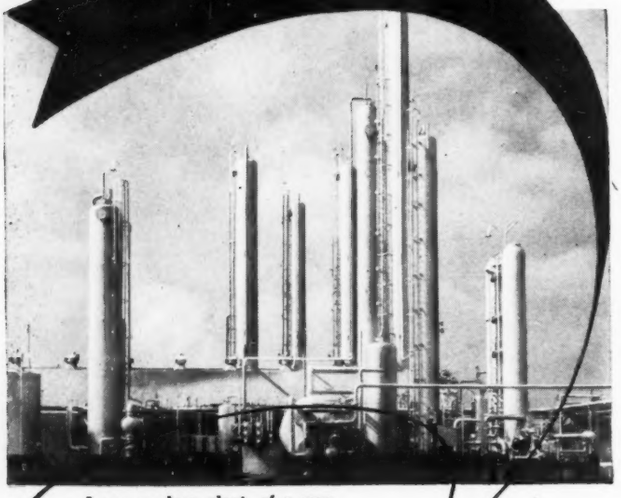
Pipe line engineers know the value of materials with which they work; we are honored by their appraisal of our product-service.

Schematic illustration at left shows successive steps in the Priming-Coating-and-Wrapping of HILL-HUBBELL Steel Pipe Protection.

Spec. TAX-1

GENERAL PAINT CORPORATION
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE SAN FRANCISCO, CALIFORNIA, U. S. A. •

Gas for Repressuring is DRIED WITH ★ Florite



Large modern plant, of a company by which FLORITE is used as a desiccant in repressuring.

Desiccation of natural gas in repressuring and in various other present-day operations, is thoroughly, efficiently, and satisfactorily done with FLORITE as the drying agent. Propane, butane, air, nitrogen, carbon dioxide, refrigeration compounds are among the materials that are successfully and economically desiccated with FLORITE. Long-term effectiveness is one of its marked advantages.

FLORITE is granular, comes in a sufficient range of mesh sizes. Hard, insoluble, chemically neutral, regenerated again and again indefinitely by heating to 350°F. Very moderate in cost.

Inquiries will be given careful, competent attention.

★ Trademark Registered.

FLORIDIN COMPANY, INC.
ADSORBENTS

182 Liberty St. Warren, Pa.

TRADE LITERATURE

What to Write For

BULLETIN CD 642, issued by Reed Roller Bit Company, Post Office Box 2119, Houston, Texas, contains information on the Reed Kor-King for conventional coring and the Reed "BR" Wire Line for intermittent or continuous coring.

THE MARLEY COMPANY, INC., Kansas City, Kansas, offer their 19-page bulletin without obligation, illustrated with photographs and drawings of their cooling towers. Information is given on applications of towers, trends and types of towers, fans and equipment, steel tower construction, water distribution, etc.

COMPLETE INFORMATION on the Vickers Hydraulic pumping units is given in Bulletin 43-24 issued by Vickers Inc., Pumping Unit Sales Engineering Office, 1400 Oakman Boulevard, Detroit, Michigan. Pictures of installations and drawings are used for illustrations. The bulletin also lists advantages and benefits to be derived from use of the hydraulic pumping unit.

FOR INFORMATION on Wagner Motors for the oil and chemical industries, Bulletin MU-182 will be sent on request containing full details on motors used in refining and chemical plants producing aviation gasoline and base materials for synthetic rubber. Address Wagner Electric Corporation, 6400 Plymouth Avenue, Saint Louis, Missouri.

THE LUNKENHEIMER COMPANY, Cincinnati, Ohio, is releasing Catalog 78 and a guide for selection of valves for various types of service, on request.

FULL DETAILS of their "Syn-Rub-Seal," synthetic rubber seal, for full opening check valves, is offered by Wheatley Brothers Pump and Valve Manufacturers, Tulsa, Oklahoma, in Bulletin E434.

CATALOG C-39-a by Armstrong Bros. Tool Company, 331 North Francisco Avenue, Chicago, Illinois, describes and illustrates fully the pipe cutters manufactured by the company. Copies of the catalog will be send on request.

ELECTRIC DRILLING RIGS to meet any drilling problem are described and illustrated with photos, charts and diagrams in a new 57-page booklet by Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. The booklet discusses features of electric drilling, tells where to use d-c., variable voltage rigs, and where to use a-c. equipment.

"THE WELDING OF PIPING" is a practical treatise of 16 well-illustrated pages. Its material consists of a series of articles prepared by Air Reduction's Applied Engineering Department. It comprehensively covers various types of ferrous and non-ferrous piping, their dimensions, fabrication, and estimates of welding and labor costs.

Copies may be procured on request to Air Reduction Company, 60 East 42nd Street, New York, New York.

A NEW 42-PAGE booklet entitled, "Factors Affecting Increased Welding Production," has been announced by The Lincoln Electric Company, Cleveland, Ohio. The contents of the booklet is divided into fifteen different sections, each of which contains up-to-date information concerning specific phases of arc welding.

Geared to the tempo of each new day . . .

FLEXIBILITY always has been a keyword with folks in the Utility Electric Power Industry. They pride themselves on the fact that electric service is something which can be adapted to almost any need, and now in these strenuous times, they prove it further.

Urgent calls requesting . . . "more kilowatts out at the new [redacted] refinery," and "How about more power immediately for that pipe line station at [redacted] " are being met with heartening efficiency.

Orders coming so fast it would make your head swim. The switchovers . . . the changes . . . to wartime production are terrific, but we're "breaking our necks" to keep everyone happy, and liking it!

If you are one of the fortunate operators using Utility Electric Power, you know what a worthwhile servant you have at your command. For the sake of victory, use it intelligently and safeguard your electric power equipment to the fullest extent.

It's power which can be *geared to the tempo of each new day . . .*

SAFEGUARD YOUR MOTORS!

- Establish a dated maintenance schedule.
- Check clearance, bearings, contact fingers, control equipment, and oil distribution transformer.
- Check air gap and varnish coils.
- Keep worn out parts for exchange on new purchases.

IT'S *Dynamite* TO OUR ENEMIES

Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

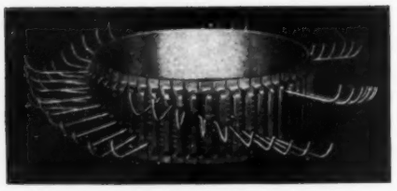
Box 1498, Oklahoma City, Oklahoma

A *Successful*

DUAL COMPLETION

Requires a

GOOD CEMENT JOB



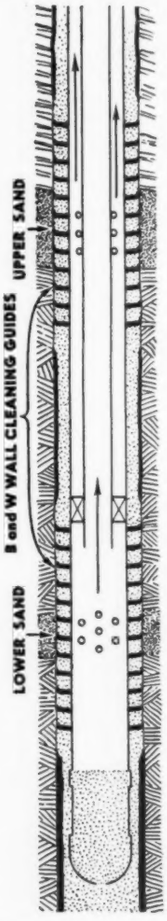
Use B and W, Inc.

WALL CLEANING GUIDES

The advantages of dual completions, including the large savings of steel, increased production, etc., indicate an increase in this type of completion during the present emergency.

The first requirement in a successful dual completion is a good cement job. A good cement job is one where the set cement entirely fills the annulus and is in bond with the formation to maintain oil, gas and water in their original position and to prevent the migration of any fluid behind the casing.

B and W Wall Cleaning Guides, placed as shown in the diagram throughout the sections to be produced, scratch off the mud cake, center the casing, and insure the proper placement of the cement slurry in bond with the formation.



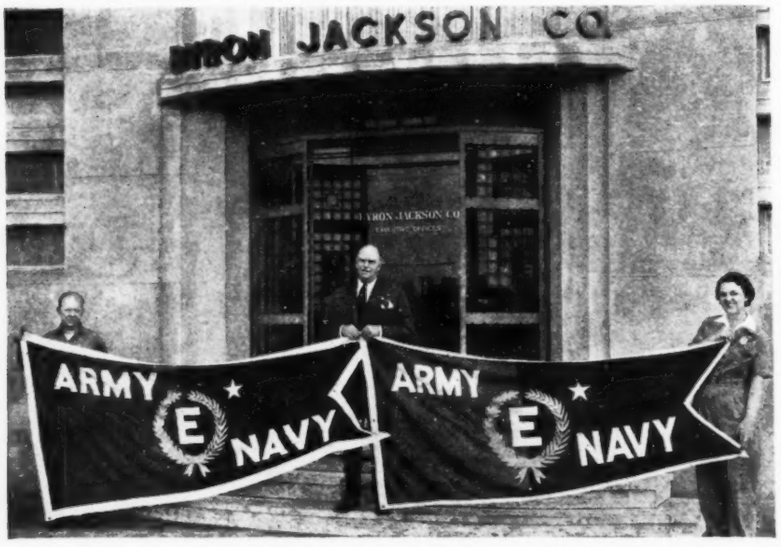
BRUCE BARKIS — B and W, Inc. — KENNETH WRIGHT

Well Completion Specialists

WEST COAST
3545 CEDAR AVENUE
LONG BEACH, CALIFORNIA
TELEPHONE: LONG BEACH 4-8366

GULF COAST
1105 COMMERCE BUILDING
HOUSTON, TEXAS
TELEPHONE: PRESTON 9783

Byron Jackson Adds Star to Army-Navy "E" Flags



E. S. Dulin, president, Mrs. Hassie Ramey, and William Powell proudly display flags with "stars" awarded for continued production achievement.

"For meritorious services on the production front" during the last six months, the War Department has awarded to Byron Jackson Company Los Angeles, California, the "star" to be added to the two Army-Navy Production Award "E" Flags presented to this concern in August, 1942. The two Los Angeles plants, which previously produced oil-well tools and centrifugal pumps, were recognized separately with a dual flag presentation last year, the first of its kind for war production.

Klumpp Made Director American Meter

American Meter Company announces the election of John B. Klumpp to its board of directors. Klumpp brings to the American Meter Company directorate experience gained in a long and distinguished career in the utility field, being recognized as one of the outstanding gas engineers in the country.

JOHN B. KLUMPP

After graduating from Stevens Institute of Technology in 1894 with an M.E. degree, he was employed by the United Gas Improvement Company and remained with that organization in various engineering capacities until 1929, at which time he resigned to engage in private practice as a consulting engineer.

Recently he has been engaged in engineering work in connection with the supplying of gas to the Army bases in and near Tampa, Florida, and by the United States Navy in making a survey of numerous large oil-fired installations in converting them to the use of coal.

LIP PROTECTORS

PATTERSON BALLAGH

CORPORATION

Los Angeles Houston New York City

Merrill Davis Passes Away

Merrill N. Davis, executive vice-president and secretary, Dresser Manufacturing Company, Bradford, Pennsylvania, who died recently, was a New

MERRILL N. DAVIS

Englander by birth, having been born at Millbridge, Maine, January 10, 1886.

When 15 years of age he went to Boston, obtained employment with Henry K. Barnes, and after two years went with the Empire Rubber Manufacturing Company as a clerk. Two and one-half years later he became connected with the B. F. Goodrich Rubber Company, as a correspondent. Later he served as Maritime Province and Newfoundland representative for the company over a period of several years. He was then assigned by the company as special representative on oil and gas field mechanical rubber goods. He resigned in 1916 to help organize the Rexhide Rubber Manufacturing Company, later becoming vice-president and sales manager. After two years with this company he returned to the Goodrich Rubber Company.

In August, 1919, Davis became associated with the Dresser Manufacturing Company, in charge of sales and advertising. In December, 1928, he was elected a director of the company and on December 10 of that year when the company was re-organized he was re-elected a director. On January 3, 1929, he was made vice-president and in May, 1932, was given the additional title of secretary.

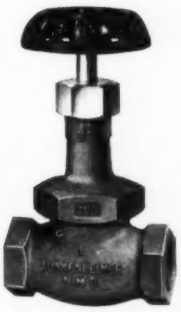
N. W. Stirling to WPB

N. W. Stirling, head of the Heat Transfer Division of The M. W. Kellogg Company, has been appointed, on a consulting basis, Production Director of the Heat Exchanger PAW of the WPB. Stirling was formerly president of the Tubular Exchanger Manufacturers Association.

Lunkenheimer Valves

Vital Helps to Industry's Needs

Bronze "Renewo"
200-300 lb. S.P.



Bronze "N-M-D"
Non-Metallic Disc
150 lb. S.P.

Bronze Regrinding
200-300 lb. S.P.

Iron Body "Ferrenewo"
150 lb. S.P.

Bronze Gate
Double Wedge Disc
125-150 lb. S.P.

Bronze Gate
Single Wedge Disc
125-300 lb. S.P.

Iron Body
"King-clip" Gate
150 lb. S.P.

Iron Body Globe
125-250 lb. S.P.

Illustrated are a few of the many types of Lunkenheimer Valves helping to produce vitally needed equipment for the Army, Navy, Maritime Commission and Air Force and other war agencies.

They're part of the complete line of valves made by Lunkenheimer for every industrial process—of bronze, iron, steel and corrosion-resistant alloys—from tiny needle types to massive power-plant valves—for 125 to 2500 lb. S.P.

A further help is Lunkenheimer's nation-wide distribution through leading supply houses. Wherever there's war activity there's a Lunkenheimer distributor serving it. Ask for Catalog 78 and the Guide for selecting Valves.

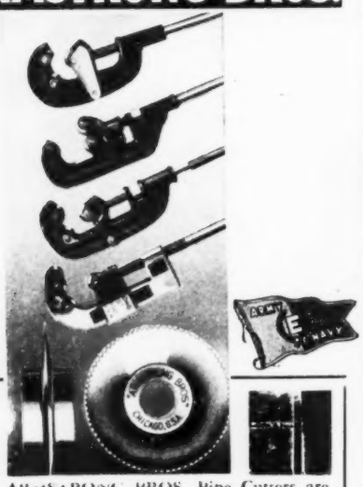
ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

Iron Body
Swing Check
125-250 lb. S.P.

Bronze Regrinding
Swing Check
200-300 lb. S.P.

BRONZE, IRON, STEEL AND CORROSION RESISTANT ALLOY VALVES, 125 TO 2500 LB. S.P.;
BOILER MOUNTINGS, LUBRICATING DEVICES, AIRCRAFT FITTINGS

Look for the Arm-and-Hammer
ARMSTRONG BROS.



All ARMSTRONG BROS. Pipe Cutters are made in all standard types. Each is a quality tool with hardened steel pins and rollers. "Saunder Type"—hardened end of thrust rod bears on inserted hard steel block (double life). In "Drop Forged" and "Combination" types, which take either 1 or 3 wheels, a replaceable hardened steel nut takes up thrust. In the "Barnes" type thrust rod threads through drop forged steel section.

ARMSTRONG BROS. Knife Blade Cutter Wheels (smooth or knurled) have thin penetrating edges that hold their keenness because they are machines from special vanadium tool steel, hardened and oil tempered. Fit all standard-make pipe cutters.

Write for Catalog C-39a

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
311 N. FRANCISCO AVE. CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York

For QUICK, ACCURATE TESTS
Use CURTIN CENTRIFUGES

No. 3420 15 c.c. machine .... Cranks and heads interchangeable with 100 c.c. machines.

Simple in design ... Ruggedly built ... Require no special care ... Great Ratio and throw of crank produce required speed with no strain. Curtin Centrifuges meet all *A.S.T.M. Standard Method D-96-40* and *A.P.I. Code No. 25* requirements. Fully descriptive literature upon request.

W·H·CURTIN & CO. Inc.
HOUSTON U·S·A TEXAS

C. R. Cox Heads Two U. S. Steel Subsidiaries

The election of Charles R. Cox as president of the National Tube Company and of Tubular Alloy Steel Corporation, has been announced by the

CHAS. R. COX

boards of directors of these two U. S. Steel subsidiaries.

Cox, who for the last two years has been executive vice-president of National Tube Company, will succeed Benjamin F. Harris, who recently resigned. Harris is now a consultant to Benjamin F. Fairless, president of U. S. Steel, in connection with war activities.

Coming to the National Tube Company from his position as superintendent of Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, in 1934, Cox was employed at the Ellwood Works, Ellwood City, Pennsylvaina, where he soon became general superintendent of the plant. In 1936, he was appointed vice-president in charge of operations, National Tube Company, with offices in Pittsburgh.

Cameron Iron Again Honored by Navy

An announcement has been made by the Navy's Public Relations Office and Cameron Iron Works, Inc., jointly, to the effect that the Navy Board for Production Awards has granted renewal of the Navy "E" Award to Cameron Iron Works, Inc., Houston, Texas, which is the fourth such award made to Cameron during the last two years.

Notification of the award was made to J. S. Abercrombie, president of Cameron Iron Works, Inc., by C. C. Bloch, Admiral, U. S. Navy (Retired), Chairman, Navy Board for Production Awards.

Bathurst to Armed Forces

William D. Bathurst, advertising manager for Clark Bros. Co., Olean, New York, has joined the armed forces. His duties with Clark have been assumed by John L. York.

Latrobe PRODUCTS
★FLOOR BOXES ★ WIRING SPECIALTIES★

"BULL DOG" PIPE OR CONDUIT HANGERS

Convenient and adaptable for a wide range of work in refineries, mills, and factories. Made of high quality malleable iron. Electro plated with cup point case hardened set screw, it holds with bull dog tenacity. Saddle turns freely for pipe to run parallel to beam or at angles.
No. 470 to hang pipe ½", ¾" and 1" to beams ⅜" thick.
No. 471 for pipe 1¼" to 1½".

"BULL DOG" INSULATOR SUPPORTS

Ideal for fastening porcelain and glass insulators to exposed steel framework—made of malleable iron.

Jobbers inquiries invited. . . : Price list and complete information upon request.

FULLMAN MANUFACTURING CO.
LATROBE . . . PENNSYLVANIA

NO DOUBLE TALK
A Guarantee that Means Precisely What It Says
Try Sand-Banum

Entirely at our risk for 30 60 or 90 Days

"The Entirely Different Boiler and Engine Treatment"

IT MUST

perform to your satisfaction or you owe us nothing. No money in advance—not even shipping charges. It removes and prevents boiler scale and corrosion.

We don't ask that you take our word for it. We will appreciate the privilege of having you prove to your own satisfaction that Sand-Banum constitutes outstanding conservation. Write today.

AMERICAN SAND-BANUM COMPANY, Inc.
9 Rockefeller Plaza, New York City

Emsco Appoints New Officers

Emsco Derrick and Equipment Company announces the appointment of W. C. Kinder and C. L. Lamkin as vice-presidents of that company, effective March 1, 1943.

Kinder entered the Emsco organization in June, 1939, as California manager of sales of the D + B Division. In January, 1941, he became assistant to the president and on March 1, 1943, was promoted to vice-president.

W. C. KINDER

C. L. LAMKIN

Lamkin entered Emsco's employ in April, 1928, in the sales department. On January 1, 1940, he was transferred to Texas as manager of Emsco's Houston plant. On March 1, 1943, he became a vice-president.

C. S. Patton Heads Exchanger Association

Cuyler S. Patton of the American Locomotive Company was elected president of the Tubular Exchanger Manufacturers Association at the annual meeting held in New York City.

CUYLER S. PATTON

Patton has been prominent in the activities of the Tubular Exchanger Manufacturers Association for many years and has served several terms on its executive committee.

At the American Locomotive Company, Patton is manager of sales for the Alco Products Division.

An Important Message to

Technical Men

The war has carried the manufacturing age to a new peak! Production demands have created technical problems the like of which the world has never seen before! The services of engineers are at a premium. Especially the services of one particular class—executive engineers—*engineers with business training;* engineers who can "run the show."

In these critical times, the nation needs engineers of executive ability *now, today*—not five, or ten years from now! The shortage of such men is acute—even more acute than that of skilled production workers. And company heads, aware of this situation, are offering high rewards to engineers who have the necessary training in industrial management.

Golden Opportunity for Engineers

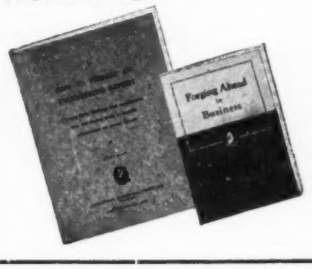
In this new era, the engineer with vision and foresight has a golden opportunity. He will realize that out of today's tremendous production battles will emerge technical men who not only will play a major role in winning the war, but who also will be firmly entrenched in key executive positions when peace comes.

However, before the engineer can take over executive responsibilities, he must acquire knowledge of the other divisions of business—of marketing, accounting and finance. He has of necessity a vast amount of technical training and experience. But in order to grasp the opportunities that present themselves today—to assume leadership on the production front—he must *also* have an understanding of practical business principles and methods.

The Alexander Hamilton Institute's intensive executive training can give you this essential business training to supplement your technical skill.

FREE help for engineers

Ever since the war began, there has been an unusually heavy demand on the part of our technically-trained subscribers for the Institute's special guide on "How to Prepare an Engineering Report". Extra copies of this practical, helpful 72-page Guide are now available and, for a limited time only, will be sent free to all technical men who use the coupon at the right.



134,000 men on the operating side of business have enrolled for this training. More than 37,500 are technical men—engineers, chemists, metallurgists—many of whom are today heads of our huge war industries.

This training appeals to engineers because it gives them access to the thinking and experience of the country's great business minds. It is especially valuable to such men because it is basic, not specialized—broad in scope, providing a thorough groundwork in the fundamentals underlying *all* business. It covers the principles that every top executive must understand. It applies to all types of industrial organizations, because all types of organizations are based on these same fundamentals.

Business and Industrial Leaders Contribute

The Institute's training plan has the endorsement of leading industrialists and business men. And it is only because these high-ranking executives recognize its value and give their cooperation that such a plan is possible. Among those who contribute to the Course are such men as Frederick W. Pickard, Vice President and Director, E. I. DuPont de Nemours & Co.; Thomas J. Watson, President, International Business Machines Corp.; James D. Mooney, President, General Motors Overseas Corp.; Clifton Slusser, Vice President, Goodyear Tire and Rubber Co. and Colby M. Chester, Chairman of the Board, General Foods Corp.

Send for "FORGING AHEAD IN BUSINESS"

The facts about the Institute's plan and what it can do for you are printed in the 64-page book, "Forging Ahead in Business". This book in its own right is well worth your reading. It might almost be called a handbook of business training. It is a book you will be glad to have in your library, and it will be sent to you without cost. Simply fill in and mail the attached coupon *today*.

Alexander Hamilton Institute, Inc.
Dept. 16, 73 West 23rd Street, New York, N. Y.
In Canada, 54 Wellington St., West, Toronto Ont.
Please mail me a copy of the 64-page book—"FORGING AHEAD IN BUSINESS" and also a copy of "HOW TO PREPARE AN ENGINEERING REPORT," both without cost.

Name.....

Business Address.....

.....

Position.....

Home Address.....

The answer to

THAT EXPLOSION ABOUT

Who wouldn't explode over the unnecessary waste caused by the corrosion of metals by sulphur, gases, salt air and humidity? And who wouldn't keep on exploding until an answer to the problem was discovered? Well, we have the answer to most cases—PARKERIZING.

Parkerizing has a broad field of usefulness because of its simplicity, economy, adaptability and rust-proofing efficiency. It will not ball up or scrape off, does not have build-up, does not cause warping, is absolutely uniform, is highly wear resistant, has long life and provides a finish of very pleasing appearance.

Being a chemical process, rather than electrolitic, the processing of hidden surfaces is as complete and effectual as outside surfaces. Being integral with the metal, it does not build up an outside coat and this fact permits maintaining manufacturing tolerances and limits.

Your investigation of Parkerizing is invited and, if you desire, we will be glad to process samples.

P. S. ***If your problem involves wearing metal parts, check into Parco-Lubrizing which prevents galling.***

WILSON ELECTRICAL EQUIPMENT COMPANY
111 N. SAMPSON C. 7136
HOUSTON, TEXAS

Licensed Processor for

PARKER - RUST - PROOF CO.

Parkerizing is a chemical treatment for iron or steel, resulting in a surface that can be stained, oiled, waxed or painted and is substantially resistant to rust.

Bonderizing is a chemical treatment for iron, steel or zinc that insures cohesion of applied coatings of paint, enamel or lacquer, resulting in longer lived, rust-resistant finish.

Parco Lubrizing is a chemical treatment for iron or steel friction surfaces, in mechanical assemblies, that improves bearing properties, retards wear and galling.

Book Reviews

The Amazing Petroleum Industry, by V. A. Kalichevsky. Published by Reinhold Publishing Corporation. Pages, 234. Price, $2.25.

A book written in language easily understandable by the layman, "The Amazing Petroleum Industry" briefly and clearly highlights the story of petroleum. It is an interesting and non-technical resumé of what petroleum is, what it does, how it is obtained, transported, and how chemists have learned to extract from it gasolines of super-performance by the "cracking" processes and the derivation of essential byproducts.

According to Kalichevsky, the "book has been written in answer to the demand for a brief popular outline of the existing petroleum manufacturing processes. Such an outline should be of assistance to college students, to young engineers beginning their careers in the petroleum industry, and to persons already connected with it, but not directly engaged in production or refining of oil. For these reasons the discussion is presented in an elementary form, omitting technical details."

Cameron Iron Acquires Ownership of Abercrombie Pump

According to an announcement by E. L. Lorehn, vice-president and general manager of Cameron Iron Works, Houston, Texas, the Abercrombie Pump Company has been purchased outright by Cameron Iron Works.

The Abercrombie Pump Company is well known throughout the oil industry, having manufactured fluid-piston slush pumps, mud line pressure gauges, shear-relief valves, and several other products for the oil industry for many years.

All products heretofore manufactured by Abercrombie Pump Company will now be manufactured and marketed by Cameron Iron Works.

Chicago Bridge Wins Award

The Pacific Coast yard of the Chicago Bridge and Iron Company at Eureka, California, received the Army-Navy Production Award for outstanding performance in wartime construction.

Commander Harry A. Shawk, Commandant of the Eureka Section Base, represented the U. S. Navy and made formal presentation of the award. Lieutenant Colonel Donn Austin, Cavalry, represented the Army and presented token pins to employee representatives. Charles S. Pillsbury, vice-president, accepted the award on behalf of the company.

SPANG
CABLE TOOLS
Conserve your equipment to bring Victory closer! And start with the best equipment you can get. For cable-system drilling and fishing, that means SPANG "Higher Standard" CABLE TOOLS. Available at supply stores.
SPANG & COMPANY
BUTLER, PA.

J. R. Jarvis of Lone Star Gas Passes Away

J. R. Jarvis, general superintendent of gasoline plants for the Lone Star Gas Company and the Lone Star Producing Company, Dallas, Texas, passed away March 27.

J. R. JARVIS

Jarvis, a graduate in chemical engineering from Texas A. and M. College, went to work for Lone Star in 1918, having previously been connected with the Galveston Gas Company and the Texas Power and Light Company. His first work with Lone Star was as laboratory assistant at the Petrolia Plant. He was placed in charge of the plant a year later and in 1924 was made supervisor of all gasoline plants.

A pioneer in the gasoline industry of the country, Jarvis at the time of his death was serving as vice-president of the Natural Gasoline Association of America, which organization he helped to found.

Los Angeles Nomads Hear Talk on Japan

A musical program and a talk on Japan were the features of the regular monthly dinner meeting of the Los Angeles Chapter of Nomads held in Los Angeles, March 10. The meeting was called to order by the retiring president, W. F. Bettis, who introduced the new officers. The president then had Billy McGraw stand and take a bow for the excellent poems he has been writing for the *Flying Carpet*, the official publication of the Los Angeles Chapter. The meeting was then turned over to the new president, Henry Pullman, who, after taking over, introduced the master of ceremonies for the evening, Earl Daniels.

The M. C. first introduced Dr. Kenneth Walker who presented a singing program based on the radio program "Sing to Win", which he originated and conducted for many months over a national hook-up.

After the musical number the master of ceremonies presented Dick Atkinson who had delivered an interesting speech on Russia at a previous meeting. After a few brief remarks on the current European situation Atkinson introduced the speaker of the evening, R. J. Purdy.

The subject of Mr. Purdy's talk was "Japan's Government of Her Colonies." The speaker had spent a considerable period of time in Japan, Manchukuo, Korea, and the occupied portion of China before Pearl Harbor, making a study of the Japanese and the way they treated conquered territory.

A large number of guests was present at the meeting among whom was Ray Dudley, Regent of the Houston Chapter. As usual there were several men from oil countries outside the United States, including Phillipi Gordon of Kern Trinidad Oilfields, Ltd.; Charles Bridgewood and C. H. Harrison of U. B. O. T. from Trinidad, and Sherman L. Pease, who was formerly with the Shell interests in Trinidad and later in Roumania.

Keuffel & Esser Receive Fourth "E" Award

Keuffel and Esser Company, Hoboken, New Jersey, manufacturers of precision instruments and equipment for engineers, draftsmen, and architects, have received their fourth "E" award—the Army-Navy Production Award with three stars. They are one of the first companies in the country to receive a fourth award.

BIG VALVES
for a Big Job

"BIG INCH" — the world's mightiest petroleum highway — needed gates that would control and direct its daily 300,000-barrel flow of liquid traffic. Ludlow Valves — mighty, themselves, yet mechanically simple and smooth in operation — got the call because that's the kind of responsibility that Ludlows have always specialized in.

War emergency — yes, but just another job for Ludlow Valves. They've been doing their daily duty throughout the petroleum industry for scores of years with maximum service and minimum maintenance. They'll continue to do so.

THE LUDLOW VALVE MFG. CO., INC.
TROY, NEW YORK PV-11

Construction Features Self-releasing 30° angle wedges and free-floating gates, self-adjusting to seats, afford smooth, trouble-free performance, long service. Rings are cleaned throughout stroke action. Gates are wedge-locked directly opposite ports and completely unwedged before raising. Ample tolerances provide easy action. Simple construction permits easy replacement of parts.

LUDLOW VALVES SINCE 1866

COLD STEEL-
BECAUSE HE NEEDS IT
WE MUST NOT
WASTE IT
Guiberson Catchers
PREVENT THE LOSS
OF PRICELESS STEEL
We cannot, we will not, we MUST not risk the life of tubing made of precious steel. And yet all production history proves that such loss CAN occur—either through parting, overloading, faulty threads and now also through enemy action. . . . For 22 years the GUIBERSON CATCHER has been the industry's accepted safeguard against this hazard — swift and positive protection at a time when the loss of the tubing may jeopardize the entire well. . . . See Composite Catalog or write for details.
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Now supplying critical materials to the Army, Navy, Marines and Army Air Forces
GUIBERSON
LIFE EXTENSION SERVICE FOR OIL WELLS

War-Time Conference Held by A.P.I.

Because of war conditions, the usual Spring Meeting of the Pacific Coast District, Division of Production, American Petroleum Institute was converted to a War-Time Conference held in the Biltmore Bowl in Los Angeles, March 23. The meeting was preceded by a dinner and consisted mainly of an address by Herbert R. Gallagher, director-in-charge, District 5 Office, Petroleum Administration for War, and of a Symposium on the "Procedure for Scheduling California Crude Oil Production During War Time."

H. R. GALLAGHER

After the dinner, Ernest K. Parks, chairman of the Pacific Coast District, called for reports of the Kettleman-Coalinga, the San Joaquin, and Los Angeles Basin Chapters, which were read by J. C. Reaves, George O. Suman, and Fred P. Miller, respectively. The treasurer's report was read by W. G. Corey.

The annual election of district officers and advisory committee was held and the following men elected:

CARLTON BEAL

Carlton Beal, chairman, Pacific Coast District; D. S. Kilgour, secretary; W. G. Corey, treasurer.

Advisory Committee—Ernest K. Parks, chairman; Carlton Beal, ex-officio; L. L. Aubert, A. H. Bell, L. A. Cranson, L. C. Decius, John F. Dodge, E. G. Gaylord, E. B. Hall, R. P. Huggins, Wm. Keck, Jr., W. N. Lacey, R. D. Montgomery, R. C. Patterson, E. E. Pyles, B. H. Robinson, J. B. Sutherland, E. P. Tallant, C. P. Watson, D. K. Weaver, J. T. Wood, and H. T. Wyatt.

Death Takes R. M. Clark

Robert Myron Clark, owner of the Owensboro Tool Company, Owensboro, Kentucky, who died recently, was born March 29, 1882, at Beverly, Ohio. He worked for the Leidecker Tool Company, Marietta, Ohio, for several years, then went to Burma in 1906 for the Burma Oil Company. Was superintendent of the machine shops at Yenangyat and Yenangyaung oilfields until 1926, when he retired, returning to the United States. He went to work for the Magnolia Petroleum Company at Duncan, Oklahoma. In 1929 he went to Owensboro, Kentucky, where he established the Owensboro Tool Company.

He is survived by his widow, Dorothea, a daughter Ellen, a son Harry who is an ensign in the Navy, and a granddaughter, Lou Ellen Clark.

McCollum and Schorp Promoted

L. F. McCollum, until recently president of The Carter Oil Company, Tulsa, Oklahoma, has assumed new duties with the Standard Oil Company (New Jersey) of which Carter is an affiliate. Oscar C. Shorp, formerly vice-president of Carter, has been advanced to president.

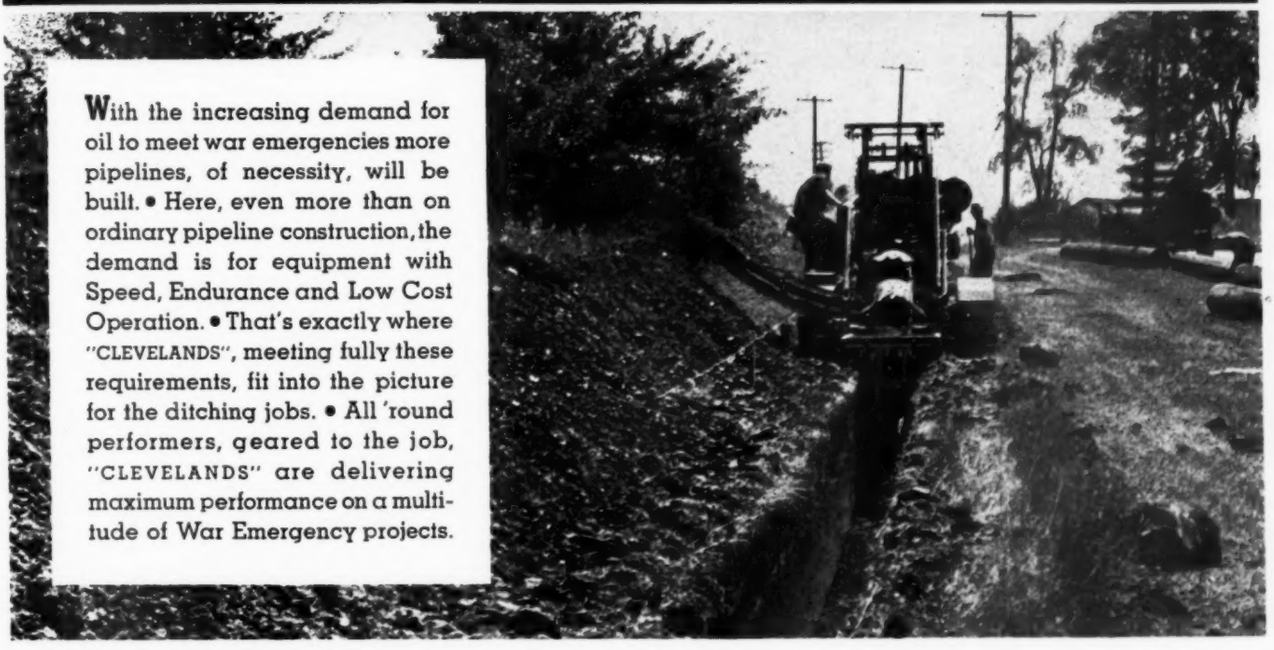
McCollum will make his headquarters at 30 Rockefeller Plaza in New York City and will become assistant to C. H. Lieb, also a former Carter president and now in charge of all producing operations of subsidiary companies of Standard Oil Company (New Jersey).

Electroweld Steel Corporation Sold

Talon, Inc., Meadville, Pennsylvania, makers of Talon Slide Fasteners, recently purchased controlling interest in the stock of Electroweld Steel Corporation, Oil City, Pennsylvania. This purchase involves no change in management.

Production of tubing will continue in the Electroweld plant at Oil City, and no product changes are anticipated.

PUT "CLEVELANDS" ON THE WAR EMERGENCY PIPELINE JOBS · · · *And Beat The Ditching Schedules*



With the increasing demand for oil to meet war emergencies more pipelines, of necessity, will be built. • Here, even more than on ordinary pipeline construction, the demand is for equipment with Speed, Endurance and Low Cost Operation. • That's exactly where "CLEVELANDS", meeting fully these requirements, fit into the picture for the ditching jobs. • All 'round performers, geared to the job, "CLEVELANDS" are delivering maximum performance on a multitude of War Emergency projects.

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. *"Pioneer of the Small Trencher"* CLEVELAND, OHIO
"CLEVELANDS" Save More . . . Because they Do More

MAKE YOUR OWN CUTTING TOOLS

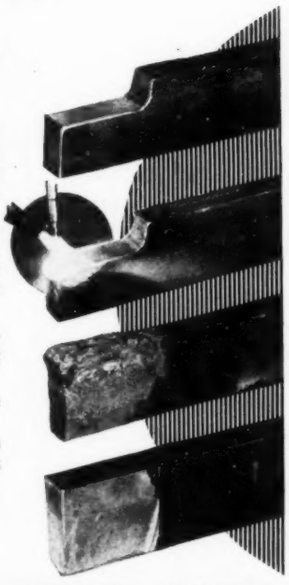
with the new

COLMONOY W C R ALLOYS

Bridge the gap between high speed steel and the carbides. Reclaim old, and make new cutting tools by welding. The process is simple.

To fabricate a typical tool

1. Undercut carbon steel shank, leaving a fillet for ease in welding.
2. Fill undercut, using ordinary hard facing welding procedure.
3. Hot wipe, to approximate shape, to save grinding.
4. Wet grind, using silicon carbide rough and finish wheels.



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Immediate delivery of all grades of W C R Alloys at all branches.

WALL-COLMONOY CORP.

720 Fisher Bldg., Detroit, Mich.
Branches in New York City, Blasdell, N. Y., Chicago, Tulsa, Los Angeles, and in Canada

ENSIGN CARBURETORS

Working for Victory

ENSIGN Carburetors for Natural Gas, Butane-Propane and Gasoline are playing an important part in the Victory effort. We are proud of this fact and are devoting our modern facilities and long experience to the successful completion of this assignment. Helping to win the war is our chief duty at this time.

But still available

ON THE HOME FRONT

However, ENSIGN Carburetors for Natural Gas, Butane-Propane and Gasoline are still available for uses not directly connected with the war effort. It may take us a little longer than usual to supply the demand for carburetors, but quick delivery of emergency parts is assured.

Now, as always, ENSIGN is unequaled for efficient and economical carburetion.

ENSIGN CARBURETOR CO., LTD.
HUNTINGTON PARK • CALIFORNIA

Prepare, NOW, for post-war demands. Our competent engineering staff is at your service.

SPERRY-SUN

SPERRY-SUN

Leader in Its Field

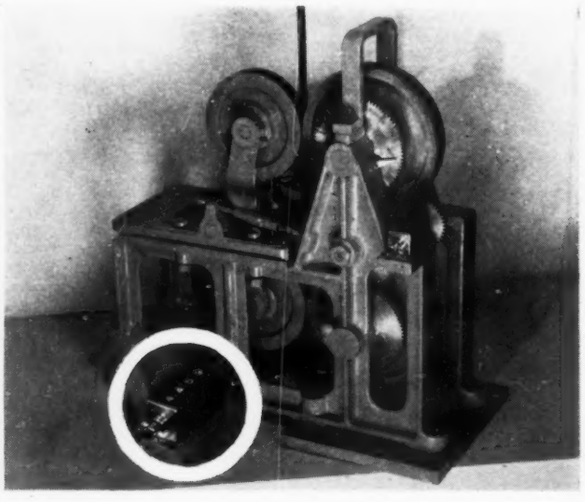
Since the discovery of the first oil well there have been many important production developments — among which Surveying Devices and Services mentioned below are recognized as outstanding contributions to the industry.

SURWEL Clinograph	H-K Single Shot
SYFO Clinograph	M-M-O Bottom Hole Orientation
E-C Inclinometer	K-K Whipstock
H-K Inclinometer	Polar Core Orientation

SPERRY-SUN WELL SURVEYING CO.

PHILADELPHIA, PA.

HOUSTON, TEXAS LONG BEACH, CALIF.



Moser Measuring Machine

ELIMINATES SCARCE MEASURING LINES

WORKS OFF SAND LINE

Good Delivery . . . Ask Your Jobber

Moser Manufacturing Co. • Kane, Pa.

CASING HEADS · PUMP JACKS · OIL COOLERS · STUFFING BOXES

PACKERS · CASING CLAMPS

MEETINGS

California Natural Gasoline Association, Monthly Meeting—May 6, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

Natural Gas Management Conference—April 28, Gibson Hotel, Cincinnati, Ohio.

American Petroleum Institute, Division of Production, Southwestern District—April 29 and 30, Rice Hotel, Houston, Texas.

Petroleum Industry Electrical Association, Annual Meeting—May 5 and 6, Houston, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—May 6, 7, and 8, Baker Hotel, Dallas, Texas.

Independent Petroleum Association of America, Midyear Meeting—May 7 and 8, Jefferson Hotel, St. Louis, Missouri.

American Petroleum Institute, Mid-Continent Section, Division of Production—May 20 and 21, Tulsa, Oklahoma.

Society of Automotive Engineers, Diesel Engine and Fuels and Lubricants Meeting—June 2 and 3, Carter Hotel, Cleveland, Ohio.

National Supply Announces Changes

Allen P. Colby has been appointed advertising manager of all divisions of The National Supply Company, whose executive offices are in Pittsburgh, Pennsylvania, and general sales offices in Toledo, Ohio. R. M. Sylvis, formerly advertising manager of Spang-Chalfant Division of National Supply Company, has been appointed assistant advertising manager, with headquarters in Pittsburgh. Colby is vice-president in charge of membership, National Industrial Advertisers' Association.

Colby has been advertising manager of the oil field division at the Toledo plant. His headquarters will remain in Toledo.

Meldrum and Fewsmith, Inc., Cleveland, Ohio, has been appointed to serve all divisions of the National Supply Company, with Clifford A. Kroening, vice-president as account executive.

Purchases Manufacturing Firm

Melvin L. Smith has purchased control of the Moser Manufacturing Company, Kane, Pennsylvania, and an entirely new management has been set up.

The new president is Melvin L. Smith, founder of the Melvin L. Smith Laboratories, Kane, manufacturers of electronic equipment. Smith is a former production and design engineer, a graduate of Penn State College, formerly production engineer of the War Production Board, and still represents industry on the Industry Advisory Committee of the War Production Board (Miscellaneous Minerals Division).

The other officers are secretary, R. C. Kreitler, plant superintendent of Melvin L. Smith Laboratories; vice-president, G. William Knapp, tool designer of the same firm, and vice-president, E. C. McDade.

Jack Daly, Jr., Receives Wings

E. J. "Jack" Daly, Jr., recently received his wings and a commission as lieutenant in the Army Air Corps at Lubbock, Texas, and has been assigned to the Air Transport Command at Del Valle Field, Austin, Texas. He is the son of E. J. Daly, Sr., Gulf Coast representative in Houston, Texas, for Wickwire Spencer Steel Company.

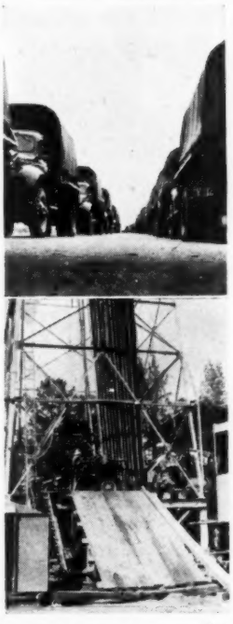
For Trucks That Must "Take It"

and Pumping Rigs, Too » »

Newly developed facilities required to meet the exacting needs of the world's toughest customer for power transmission control in heavy - duty trucks, tractors and other war machines, have produced more rugged and DEPENDable types and sizes of

ROCKFORD CLUTCHES *and Power* TAKE-OFFS

With men staking their lives on the reliability of power transmission, all "maybe" has been engineered out of power units going into war machines. And one day, this new degree of ruggedness and dependability will help improve oil field prospecting, drilling, pumping, hoisting, current-generating and back-filling equipment.



There is no priority on planning. Now, when you are designing your post-war models, is the time to let our engineers give you the benefit of their war - gained experience. Their recommendations will help you specify clutches and power take-offs that will give your peace - time equipment competitive construction advantages.

SEND FOR THESE HANDY BULLETINS ON POWER TRANSMISSION CONTROL

Show HOW the money-saving advantages of ROCKFORD CLUTCHES and Power TAKE-OFFS improve the efficiency and economy of power units. Give capacities, dimensions, shaft sizes, types of bearings and other specifications.

Rockford Drilling Machine Division *Borg-Warner Corporation*

1303 Eighteenth Ave., Rockford, Illinois, U. S. A.

USE ROCKFORD INDUSTRIAL CLUTCHES FOR SUPERIOR PERFORMANCE AND ECONOMY

Machine Tools | Process Machinery | Farm Implements | Materials Handling | Earth Movers | Service Machinery | Power Units

Fullmetal Multiple-Disc Clutches • Over-Center and Spring-Loaded Clutches • Power Take-Offs

THESE 3 Westco ADVANTAGES

MEAN IMPORTANT SAVINGS IN YOUR PUMPING JOBS!

TWO-STAGE PERFORMANCE AT SINGLE-STAGE COST

PERMIT FUTURE EXPANSION OF SYSTEM

PROVIDE STANDBY PROTECTION AT LOWEST COST

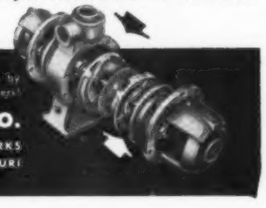
▶ Because of the unique turbine design of Westco Pumps, a *single*-stage Westco will continuously supply high operating pressures that would require a *two*-stage centrifugal pump. Thus, Westcos save on *first* cost...on *operating* cost...*on maintenance!*

▶ Westco operating characteristics are such that additional outlets can be handled with *decreasing* horsepower requirements... whereas centrifugals would require *additional power* to maintain operating efficiency. In this way, Westcos reduce *both* cost of expansion and cost of operation if future additions to system become necessary.

▶ Westco's *renewable liner* feature eliminates need for an entire separate pump assembly for safe stand-by protection. By simply keeping an extra liner assembly on hand, Westcos can be quickly and economically renewed at a *fraction* of ordinary cost.

Get the full Westco story of peak performance at unusually low installation and operating costs before you invest in ANY pump equipment. Ask your Westco dealer — or write direct!

On Westco Pumps, wear and corrosion are taken by *renewable* liners. To renew pump, simply renew liners!

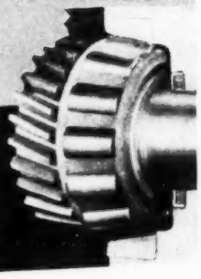


WESTCO-POMONA PUMP CO.

DIVISION OF JOSHUA HENDY IRON WORKS

2621 LOCUST AVENUE, ST. LOUIS, MISSOURI

TIMKEN ROLLER BEARINGS in a SINGLE CYLINDER ENGINE?



Certainly—if it's a **WISCONSIN AIR-COOLED ENGINE**

No Wisconsin Engine, so far as we know, has ever had a case of "Bearing Failure." Basically, this is an end result of using Timken Roller Bearings at both ends of the crankshaft. Normally, small engines are not provided with this safeguard . . . but every Wisconsin Engine, whether single cylinder or 4 Cyl.; 1 hp. or 35 hp., has this heavy-duty service protection.

This is a typical example of Wisconsin Air-Cooled Heavy-Duty Engine design and construction . . . geared to maximum utilization of power-operated equipment.

MOST POWER Per POUND

WISCONSIN MOTOR Corporation

MILWAUKEE, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.

510 ATLAS BLDG., TULSA, OKLA.

M & W BLDG., HOUSTON, TEXAS

OIL FIELD DISTRIBUTOR FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

One of us is wrong!

You think, unless you now use JENSEN JACKS, that you know a better way to pump a well.

But we have made JENSEN pumping equipment and have compared it with other pumping equipment for 24 years, and we think you are wrong. So do many of the best producers in the country. No man likes to have his judgment questioned and we aren't questioning yours. But we do suggest that you investigate.

JENSEN

BROTHERS MFG. CO.

Coffeyville, Kansas, U. S. A.

Export Office: 50 CHURCH STREET, NEW YORK CITY

WEIGHT INDICATOR POINTS

Brass and bronze—important ingredients in Martin-Decker Indicators and Gauges—have got to be right to give you the ultimate in instrument accuracy, ruggedness, long life. So . . . to take no chances on brass parts having "pin holes," scale inclusions, etc. . . . all castings are made *under Martin-Decker's close supervision and control at one brass foundry.* This insures HIGHEST QUALITY and uninterrupted service of the Martin-Decker instruments you use.

Matter of fact, similar control of steel . . . rubber . . . aluminum . . . copper . . . and other important materials plays a big part in giving you the finest of instruments for any weight or pressure control job on the rig.

MARTIN-DECKER CORP.
LONG BEACH, CALIFORNIA
A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
REED ROLLER BIT CO., HOUSTON, TEXAS

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